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THE MANUFACTURE OF ALUMINUM.

THE manufacture of aluminum has recently made great progress. It is now more than twenty years ago that it was announced that this metal was to fulfill an important role in the industries, owing to its remarkable properties, which assign a rank to it intermediate between the precious and the common metals, and particularly owing to its great lightness. It has now become possible to obtain it at a net cost much nearer that of the common metals than the lowest cost of the precious ones. It possesses, besides, the advantage of being inoxidizable, of having neither odor nor taste, and that its salts are entirely innocuous.

The discovery of aluminum, which dates back to 1827, is due to Wohler. This celebrated chemist at that epoch obtained a few globules of a semi-metallic aspect, and of the size of a pin's head, on decomposing hot anhydrous chloride of aluminum with potassium.

It was evident that the properties of the new metal thus isolated could not be studied with so small quantities. It was, moreover, so impure that it was impossible to unite the globules into one mass by melting them, and, when we think of the exorbitant price of potassium at that epoch, we are not surprised that Wohler did not continue his work with a view to an industrial application. But he had opened the way, and, in 1859, Henri Sainte-Claire-Deville, after a series of laborious and remarkable experiments, prepared the metal in a state of purity, made known its properties, and improved Wohler's method, or rather converted it into an industrial process, by simultaneously creating three new industries which were to furnish him with the elements for the manufacture of aluminum.

The definite installation of Sainte-Claire-Deville's process was organized at the Salindres works by Mr. Henri Merle, their founder. For many years there was here produced a metal which was irreproachable as to quality, and it is from these works that, up to a recent period, nearly all of the aluminum used in the industries has been derived.

But the price of the metal was too high to allow it to be used for all the purposes that its qualities recommended it.

As might have been expected, new methods of extraction were to be devised, and it is the electric current, which, by its power of chemical decomposition, has led to the remarkable results that now permit of delivering aluminum at a price five times lower than that of only a few months ago.

PROPERTIES OF ALUMINUM.

Aluminum is a white metal with a slightly bluish shade that distinguishes it from silver. Like the latter, it may be polished and burnished, or a beautiful dead surface may be given to it that will last indefinitely. Its melting point is intermediate between that of silver and that of zinc. Its electric conductivity is comparable to that of silver, and is about eight times that of iron.

In a state of purity, it is very ductile and very malleable. It is the only metal that can, like gold and silver, be brought, by beating, to the state of leaves of extreme tenacity, or be converted into very fine wire as tenacious as that made of silver. It can be forged, drawn out cold, chased and stamped, and be struck into medals of rare perfection; in a word, it can be worked in every way with great ease. It possesses a remarkable sonorousness. Thus, a bar of aluminum, suspended at the center by a thread, renders, when struck, an intense, clear, and very prolonged sound, comparable, as regards purity, with that of crystal glass.

But the special peculiarity of this metal, and that which surprises those who handle it for the first time, is its very feeble density (2·66). The metal, in fact, is as light as glass; that is to say, it weighs three and a half times less than copper.

From a chemical point of view, it possesses valuable properties. It oxidizes neither in dry nor moist air, it is attacked neither by sulphur nor sulphureted gases, and it resists in a cold state both sulphuric and nitric acids; in a word, it is, at the ordinary temperature, very refractory to the corrosive agents that attack metals in general. But when, under certain circumstances, it has combined with a metalloid, it remains so combined with great obstinacy, and it requires a great energy to separate it from its combinations.

Before examining the principal applications of aluminum, we shall pass in review the most interesting processes of manufacture. These are at present divided into two classes—chemical and electrolytic.

CHEMICAL PROCESSES.

It may be said, in a general way, that the production of aluminum by purely chemical means is effected by but one and the same process, that of Sainte-Claire-Deville, who has made known with great precision every part of his system and the variations that can be made in it, so that the different chemical processes since devised are but local and not very striking modifications of the primitive system. We shall therefore confine ourselves to a description of the latter.

The Sainte-Claire-Deville process comprises the following operations: Preparation of pure alumina; preparation of chloride of aluminum; preparation of sodium; reduction of the chloride of aluminum by the sodium.

Preparation of Pure Alumina.—Alumina is found very abundantly distributed in nature, especially in the form of silicates. In the south of France, especially in the departments of the Var, of the Herault, and of the Bouches-du-Rhone, we find an abundance of a very rich mineral called bauxite, which contains about 70 per cent. of alumina, the rest of its constituents being iron, silica, and water. It is principally from this bauxite that pure alumina is extracted.

After the bauxite has been crushed, it is mixed with a certain proportion of carbonate of soda and is put into a highly heated reverberatory furnace. Aluminate of soda is thus formed.

The crude product of the calcination is removed from the furnace and is lixiviated in order to extract the aluminate, which is very soluble. The iron and the silicates are insoluble and are separated from the solution. This solution is treated cold with gaseous carbonic acid, which takes up the soda combined with the alumina and allows the latter to deposit in a pure state at the bottom of the vessel, which then contains a solution of carbonate of soda. They are separated by filtration, and the alumina, washed and dried, is ready to be used for the preparation of—

Chloride of Aluminum.—This is prepared with the pure alumina associated with an equivalent proportion of chloride of sodium to form a double chloride of aluminum and sodium, which is much more stable and manageable than the simple chloride.

Balls composed of dry alumina, carbon, and sea salt are made with a little oil of tar as an agglomerant, and are introduced into a vertical retort of refractory clay heated to a bright red. A current of dry chlorine is introduced at the bottom, and this unites with the aluminum to form a chloride. This latter unites with the chloride of sodium, and the double chloride, thus formed, distills, escapes through a tubulure at the top and is condensed and collected in a chamber arranged for the purpose.

Preparation of the Sodium.—The sodium is extracted from soda or its carbonate. It is the latter that is generally used, and it is mixed in proper proportions with coal and chalk. This composition is introduced into iron tubes, entirely closed at one extremity and provided at the other with an eduction tube connected with a condensing receiver.

These tubes are raised to a bright red heat in a furnace. The sodium distills in the interior and condenses in the receiver, whence it is made to flow under naphtha, in order to prevent the rapid oxidation that it would undergo in the air.

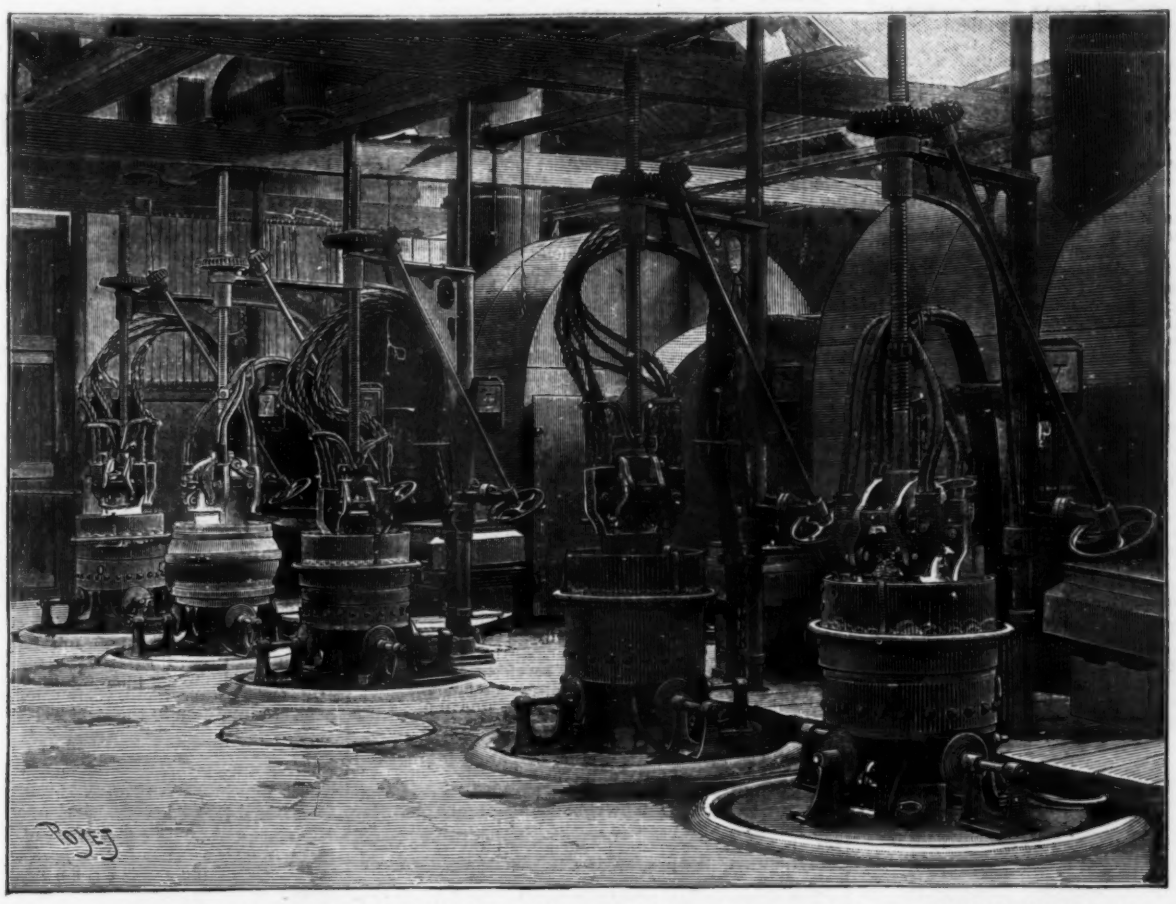


FIG. 1.—GENERAL VIEW OF THE CRUCIBLES FOR THE MANUFACTURE OF PURE ALUMINUM AT THE FROGES WORKS.

Production of the Aluminum.—After all the parts that are to permit of isolating aluminum have thus been prepared, about

10 parts, by weight, of double chloride,
5 " " " cryolite,
2 " " " sodium,

are taken, and the mixture is thrown upon the dead plate of a small reverberatory furnace which has previously been raised to a red heat. A very tumultuous action is produced, with very violent upheavals. The materials are heated for about four hours, at the end of which the operation is finished, and the metal that has formed amid the melted residue is drawn off.

The Cryolite Process.—As has been pointed out by Sainte-Claire-Deville, aluminum may be obtained by causing sodium to react upon cryolite in a state of fusion. This mineral, which is found in workable strata in Greenland only, is a double fluoride of aluminum and sodium. It contains about 13 per cent. of aluminum, but its treatment by sodium has always presented great difficulties, and the rendering in metal has always been very small. This is the process that is practiced at the Wallsend Works, near Newcastle-on-Tyne (England), and the description of which we borrow from *Industries*.

Fig. 2 represents a battery of furnaces designed for the preparation of the metal. They are established in a continuous line, and each of them occupies 8×8 feet of space and is 6 feet in height. In the center there is a cast iron retort 3 feet in height and 2 in diameter, with a tapping pipe in front. A cylindrical box at the top, luted with slaked lime so as to secure tightness, serves for the filling, and is provided with a tube to which is fixed the sodium condenser.

The retort, previously heated, receives a charge of gas coal, which is raised to a bright red. Then a charge of fused caustic soda (prepared to this effect in a cast iron vessel heated by the waste heat of the furnace) is slowly introduced by means of a siphon. The sodium flows over the surface of the ignited carbon, and, in a few minutes, clouds of vapor escape from the retort and burn with a beautiful yellow flame at the orifice of the condenser. The metallic sodium flows in drops from the condenser into cast iron troughs that serve to carry it quickly to tight receptacles of the same metal, whence it is removed for ulterior uses. Each retort produces about 60 pounds of sodium per day, and requires constant watching to prevent the condenser from being obstructed.

Fig. 3 represents the furnaces employed for fusing the cryolite. They are reverberatory furnaces, and are charged at the top with a mixture of cryolite and sea salt. After fusion, the product is drawn off into an iron converter, mounted upon a truck and capable of being turned over by means of a system of gearings.

Fig. 4 shows the work of introduction and stirring of the sodium into the fused cryolite. As soon as the sodium enters the converter, two men insert a ladle in the mass, and work it up and down until the end of the reaction. It only remains to remove the dross and collect a button of aluminum at the botton of the converter.

This process yields scarcely 8 per cent. of metal in proportion to the weight of cryolite used, and it requires about 9 lb. of sodium to obtain 1½ lb. of aluminum.

When it is desired to obtain a purer metal, the operation is performed in clay crucibles placed in a furnace, and that permit of more easily regulating the work, especially the stirring. These are first heated and then there is introduced into them a block of aluminum fixed to an iron rod that has a perforated cover screwed to it.

The products obtained contain from 90 to 99 per cent. of aluminum. As the dross always retains a little of the metal, it is remelted in the furnace along with copper, in order to form an aluminum bronze.

ELECTROLYTIC PROCESSES.

The manufacture of aluminum by chemical processes, at least in France, has nearly died out, and is tending to be replaced by electrolytic processes, which are much simpler and more advantageous. These electrolytic processes are of two kinds, one of them furnishing

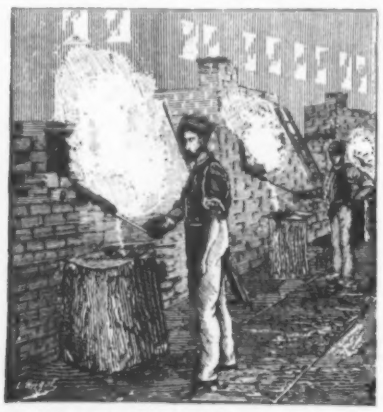


FIG. 2.—CRYOLITE PROCESS FOR THE MANUFACTURE OF SODIUM.

aluminum in a state of alloy with another metal, and the other giving the pure metal at once.

The Cowles Process.—This process, which, it appears, is exploited in America and England, has not yet been used in France. The Cowles furnaces have often been modified in form, and we do not know which one has been definitely adopted.

The essential principle of this process is the dissociation of alumina under the influence of a very high temperature, when it is put in the presence of carbon and of a metal having a strong affinity for aluminum. These conditions are realized by forming a pulverulent mass consisting of alumina, carbon, and the metal that it is desired to alloy with aluminum (copper, for example). Two rods of carbon are placed opposite each other at the extremities of the mass in question, and a current of the proper power, under a tension of 75 or 80 volts, is passed through them.

There is thus obtained an extremely high temperature, under the influence of which the following reaction takes place:

$$Al^2O^3+3C+nCu=Al^2Cu^n+3CO.$$

As may be seen, there is here no electrolytic action. The electric current is ingeniously put to contribution as a source of intense heat, and may be utilized in two forms, continuous or alternating.

According to the inventors of the process, one part of the alloy flows off, and the other volatilizes and is collected by condensing the metallic vapors in special apparatus. It appears to us to be a difficult thing to remelt an alloy of aluminum under the extra tenuous form that it has in this case, for it oxidizes in great part, and what remains in the metallic state does not conglomerate. While considering the Cowles process

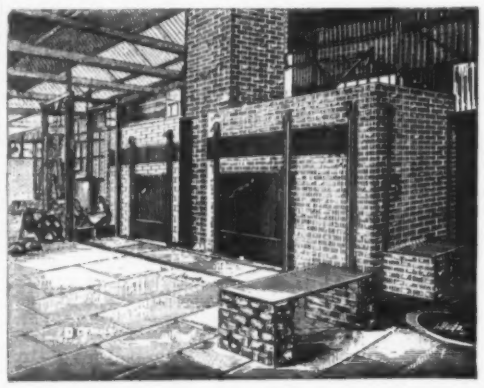


FIG. 3.—FURNACE FOR THE FUSION OF CRYOLITE.

as meriting attention, we do not believe, then, that it can be easily applied to the production of pure aluminum.

The Minet Process.—The process patented by Mr. A. Minet, on the contrary, permits, according to its inventor, of obtaining pure aluminum by sacrificing one part of the production to the other part. The electrolyte recommended by the inventor is fluoride of aluminum. To this he adds fluoride and chloride of sodium for the purpose of rendering it more fusible.

His apparatus consists of an iron vessel heated externally, upon the bottom of which rests a carbon cupel, leaving a sufficient space between it and the sides. Above this cupel there is a vertical carbon rod constituting the negative pole. A second rod, parallel with the other, forms the positive pole. The iron vessel itself communicates with the negative pole through the intermedium of a resistance that gives passage to a part of the current only.

After the vessel has been filled with fluoride of aluminum and the latter has been melted by heating the apparatus upon a furnace arranged for the purpose, the current is passed through it. The electrolytic action decomposes the fluoride. The aluminum goes in part to the negative carbon electrode and falls into the cupel and in part to the iron vessel. There is thus formed permanently upon the inside an iron aluminum alloy, which prevents the fluoride from attacking it, and from introducing iron into the bath in fusion. As well known, 2 per cent. of this metal strongly contaminates aluminum.

This artifice, which is efficacious as regards the protection of the electrolyzed metal, has the inconvenience, however, of necessarily producing an iron aluminum alloy, and that too at the expense of the apparatus itself, which is rapidly put out of service. Moreover, at the positive pole, there occurs a disengagement of fluorine, which it must be very difficult to guard one's self against.

The cost of the aluminum is subordinate to that of the fluoride, and the latter must be pure if it is desired to obtain a good quality of metal.

The Heroult Processes.—We now come to the very complete processes devised by the young French engineer Mr. Heroult, who was one of the first to undertake researches upon the extraction of aluminum by the electrolytic way. We propose to describe them in some detail.

The characteristic point common to the Heroult processes is that they treat alumina directly.

H. Sainte-Claire-Deville, in his remarkable work upon aluminum, after a *resumé* of what had been done by others, and of the difficulties overcome, says: "The reduction of alumina by a direct process is still out of our power." To-day the question is solved. In a patent of the date of April 23, 1886, Mr. Heroult claimed the electrolysis of alumina dissolved in fused cryolite in order to obtain pure aluminum. In an addition dated April 15, 1888, he claims the electrolysis of melted alumina by the action of the current itself. In this latter case the bottom of the vessel is formed of the metal of which it is desired to obtain an alloy, and constitutes the negative pole.

The application of these processes is already beginning to extend very widely in Europe. For several months, the Neuhasen Works, at the falls of the Rhine, where they have at their disposal a power of 2,000 horses, and the Froges Works, at 12 miles from Grenoble, have been daily producing large quantities of pure aluminum, at the rate of half an ounce per horse hour.

The Froges Works, Fig. 1.—The Froges Works have at their disposal a hydraulic power of 800 horses, and two turbines of 300 h. p. each, and a small one of 100 h. p. The large turbines actuate four dynamos, each producing 6,000 amperes and 15 volts; they are machines of feeble tension and continuous current. The small 100 h. p. turbine actuates an exciter of 500 amperes and 65 volts, which concurs likewise in the lighting of the works. This same turbine also actuates all the machine tools of the works. The apparatus (Fig. 5) used for the manufacture of pure aluminum consists of an iron plate crucible lined with carbon and insulated upon supports. This crucible has an aperture in the bottom to allow of the passage of one of the electrodes, which is insulated electrically from the rest of the vessel. The other electrode is suspended above the crucible by a bracket provided with a screw which permits of raising or lowering it at will. This upper electrode, which is the positive one, is of carbon. The lower and negative electrode may be formed of any metal whatever.

A certain quantity of cryolite is put into the crucible. The current immediately passes, and the operation is continued without interruption, provided that care is taken to keep up the bath constantly by adding to it alumina, which the electric current decomposes. The metal deposits at the bottom of the crucible, whence it is drawn off every twenty-four hours.

The metal thus obtained should be chemically pure. Unfortunately, the substances employed are not themselves of absolute purity. So it is rare that aluminum of more than 99 per cent. is obtained. When the bath is charged with impurities, the degree of purity of the metal gradually lowers; there is nothing to do then but to renew the entire bath. This is what is done at Froges, where aluminum of less than 97 5 per cent. is never taken out. A very complete laboratory installed in the works permits of an immediate analysis of each running, and of controlling the purity of the metal in a constant manner.

The apparatus that serves for the direct preparation of the alloys of alumnum is shown in Fig. 6. The principal alloys prepared are aluminum bronze and ferro-aluminum.

The current, in order to pass from the electrode, C, to the iron or copper which is at F, is obliged to traverse the stratum of alumina. As the latter offers a very great resistance to the passage of the current, there results a great elevation of temperature, under the influence of which the alumina melts into a perfectly fluid state, thus constituting a simple electrolyte which the current separates into its elements, that is, aluminum, which goes to the iron or copper—the negative electrode—and oxygen, which is disengaged in contact with the anode, C, and forms oxide of carbon, which burns upon making its exit from the aperture, O. The temperature at A is such that any other substance than carbon would quickly melt there.

The charging is done at regular intervals with the proper proportions of alumina and the metal to be alloyed. When the crucible is full, the metal is drawn off by removing the plug, T.

The proportion of aluminum in these alloys may vary from 8 to 30 per cent. The production of aluminum is equal to half an ounce per horse hour. By substituting silica for alumina in this same apparatus, silicious copper, rich in silica, may be prepared and serve for forming silicious bronzes.

The Froges Works manufacture their own agglomerated carbon electrodes, and the regular quality and purity of these permits the establishment to produce a very pure metal with certainty.

PRINCIPAL APPLICATION OF ALUMINUM AND ITS ALLOYS.

Through the processes just described, it is possible to manufacture at will, at the Froges Works, bronze aluminum, ferro-aluminum, or pure aluminum.

To speak of these three products only, it may be said that they are of a nature to revolutionize the metallurgic art industries.

Numerous experiments have confirmed the opinion already stated, that the use of aluminum is capable of rendering great services in the metallurgy of iron and its derivatives. One one-thousandth of aluminum, put into a running of steel, purges the metal, renders it fluid, and permits of casting it without air holes or cracks. One ten-thousandth in iron permits of casting it without fissures or air holes, prevents the thin parts from becoming brittle, and gives the metal a remarkable impermeability—a matter of great importance as regards pressure apparatus.

This proportion of one one-thousandth of aluminum and the use of ferro-aluminum in steel works is still under discussion in France. Meanwhile, the Creusot Works are employing pure aluminum in large quantities. On another hand, there is a great consumption of ferro-aluminum in the steel works of Germany. The

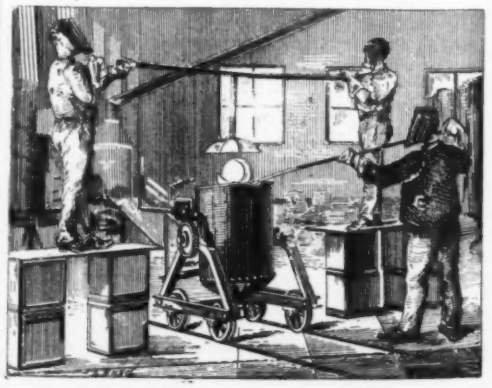


FIG. 4.—INTRODUCTION OF SODIUM INTO THE FUSED CRYOLITE.

German works do not allow their processes to be made known no more than they do the method of using or the proportion to be employed. The proportions are doubtless variable with the nature of the metal to be treated. Aluminum bronze and brass also have remarkable properties. The bronze has a much greater resistance than the brass, and its elongation is less. It is of a beautiful golden yellow, and its hardness is such that it has to be introduced into the rolling mill in a peculiar way.

Pure aluminum may be put to numerous applications in domestic life. Thus, its lightness, and its not being attacked by the air, hydro-sulphuric acid, etc., render it very convenient for use in table services. We may mention, too, its use in articles of jewelry, optical instruments, harness, locksmith's work, musical instruments, instruments of precision, geodesy, and surgery, military telegraphy, chandeliers, etc.

The properties of this metal, it would seem, ought to cause it to be selected for advantageously replacing copper in our small coin, which is so heavy and inconvenient. In addition to the fact that it is inoxidizable, its extreme lightness would render the new coin very portable and handy. Moreover, owing to such lightness, we should not need, as with nickel, to give special forms to the new pieces in order to prevent them from being confounded with the existing silver pieces. The lightness of pure aluminum is such that it weighs four times less than silver, and that a piece of it of the

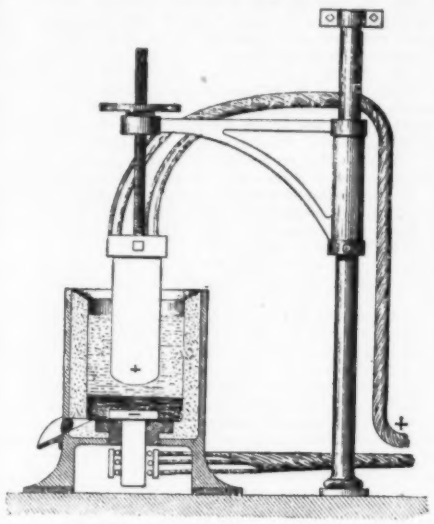


FIG. 5.—HEROULT APPARATUS FOR THE MANUFACTURE OF PURE ALUMINUM.

bulk of a silver two franc piece would weigh no more than a silver fifty centime piece.

One of the most interesting applications of aluminum is in aerostation. Thus, as regards the steering of balloons, we should try to produce the greatest force possible and carry as little weight as possible in the car. It would therefore prove of great interest to have a motor both very powerful and very light. The propagators of this important question are at present studying the use of aluminum, the feeble density of which is of a nature to facilitate the solution of the difficult problem of aerial navigation.

What, however, is going hereafter to singularly facilitate the applications of aluminum and give an impetus to its consumption is the great decline in its net cost, and which results from the use of the new processes that we have just described. In order to give an idea of this, it will suffice to recall that a pound of aluminum, which was worth about ten dollars until quite recently, costs to-day no more than two or three, and this price will even descend below a dollar and a half, when the extension of the use of this metal shall permit of manufacturing it on a larger scale and of thus reducing the general expenses of the producing works.

Among the applications of aluminum bronze, we may note the one that has just been made in France to the screws of ships. The French Metallurgical Society is likewise using its bronze with success for the manufacture of cocks for paper machinery, and for bearings, slide valves, and locomotive pistons for our large railway companies.

The following table gives the result of experiments made to ascertain the resistances and elongations of aluminum bronze and brass. The first series was made at the Polytechnic of Zurich, and the second in the laboratory of the Froges Works:

Metals.	Resistance in kilogs. per sq. millimeter.	Elongation. Per cent.	Total coefficients of quality.	
Cast steel	57	14	71	Experiments at the Polytechnic.
Forged iron	58	22	80	
Delta metal	38	20	58	
Phosphor bronze	29	17	48	
Manganese "	29	17	48	
Cannon "	32	56	88	
Aluminum bronzes according to proportions	61	11	77	
	58	24	82	
	55	35	90	
Ditto, cast in plaster moulds	58	22	80	
	52	31	83	
	58	26	84	
Aluminum brasses according to composition	44	36	80	Experiments at the Froges Works.
	48	33	81	
	41	45	86	
	42	48	90	
	42	50	92	
	44	49	93	
	42·5	53	95·5	
	44·6	15	59·60	
Aluminum bronzes cast in sand	45·7	12	57·70	
	41	20	61	
	42	41	83	
	32	10	42	
Aluminum brasses cast in sand	31	18·5	49·5	
	31·8	19	50·8	
	32·8	22	54·8	

These results show that aluminum bronze and brass possess remarkable mechanical properties.—*C. Talansier, in Le Genie Civil.*

THE ROLLET PROCESS.

ON THE ROLLET PROCESS FOR PRODUCING PURIFIED CASTINGS.*

By Mr. A. ROLLET, Paris.

PIG iron or castings, steel and iron, generally contain more or less sulphur, phosphorus, silicon, and other substances tending either to improve or to deteriorate their qualities. Sulphur and phosphorus are usually the only impurities that are taken into consideration in castings of steel or of iron.

* Paper read before the Iron and Steel Institute.—*Engineering.*

In refining so-called pure castings for iron or steel in the presence of an acid slag by any of the ordinary processes, products are obtained which contain the greater part of the sulphur and all the phosphorus contained in the castings treated. It even happens in the Siemens furnace that the refined (decarburized) product is more sulphurous than the bath at the commencement. When phosphoric castings are refined for iron or steel in the presence of a basic slag by one of the ordinary processes, the products obtained contain much less phosphorus than either the castings or the bath at the commencement. They retain, however, a notable portion of the sulphur.

In either case, the steel or iron obtained is of mediocre or indifferent quality.

It is, moreover, well known that steels obtained in

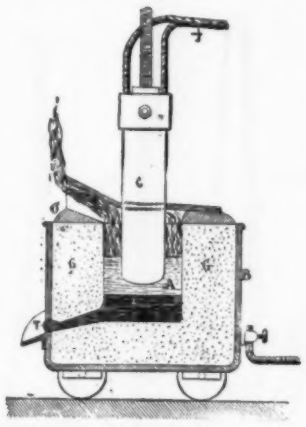


FIG. 6.—HEROULT APPARATUS FOR THE MANUFACTURE OF ALLOYS OF ALUMINUM.

B, Cast iron vessel. G G, Lining of conducting carbon in which there is a space forming the laboratory of the apparatus. The vessel, B, and the carbon communicate with the negative pole of the dynamo. C, Carbon electrodes forming the positive pole of the apparatus and performing the role of reducing anode. A, Bath of alumina melted and electrolyzed by the current. F, Metallic bath of iron or copper occupying the bottom of the crucible. O, Orifice through which the alumina and metal are introduced, and through which the oxide of carbon makes its exit. T, Tap hole closed with a carbon plug.

the presence of an acid slag have special qualities, different from those of steels containing the same percentage of sulphur, phosphorus, and other impurities obtained in the presence of a more or less ferruginous basic slag, and that crucible steel, which is obtained in the presence of the most acid and least ferruginous of all slags, possesses properties peculiarly its own.

Therefore special steel, such as is employed in certain industries, *e. g.*, for the manufacture of ordnance, tools, etc., is preferably, or rather exclusively, made by melting on an acid bottom (or heart), or in crucibles, such pure materials as are comprised in the same category as charcoal irons and the best brands of Swedish iron.

The process of fining castings, as here described, is intended to be auxiliary to the manufacture of special qualities of steel, its object being to eliminate sulphur, phosphorus, and silicon from the castings. It consists in melting castings or pig, or maintaining them at a very high temperature under a double action, slightly reducing and slightly oxidizing, in the presence of a slag obtained by admixtures of limestone or lime, iron ores, and fluorspar, in proportions depending on the quality of the pig or castings employed.

The apparatus I employ for this purpose is a blast furnace or modified cupola, using coke and hot blast. The burdens are introduced in the same way as in blast furnaces and cupolas.

It consists of a part, A, an independent shaft, C, several rows of tuyeres, F F F, a siphon arrangement, S S, for separating metal from slag, and a front chamber, D.

Externally, it is composed of sheet iron and steel; internally, at the bottom it is lined with any suitable refractory material, preferably with magnesia. It is cooled externally at all parts liable to injury by currents of cold water.

The tuyeres are arranged in several rows, above one another. They are water tuyeres, and project into the furnace. The hearth is situated as near as possible to the lower row of tuyeres. A single hole serves for tapping both the metal and the slag. In tapping, the metal is separated from the slag by means of the siphon, S S, which is so arranged in relation to the hole as to prevent the blast from blowing through. The metal flows out at O, and the slag at S.

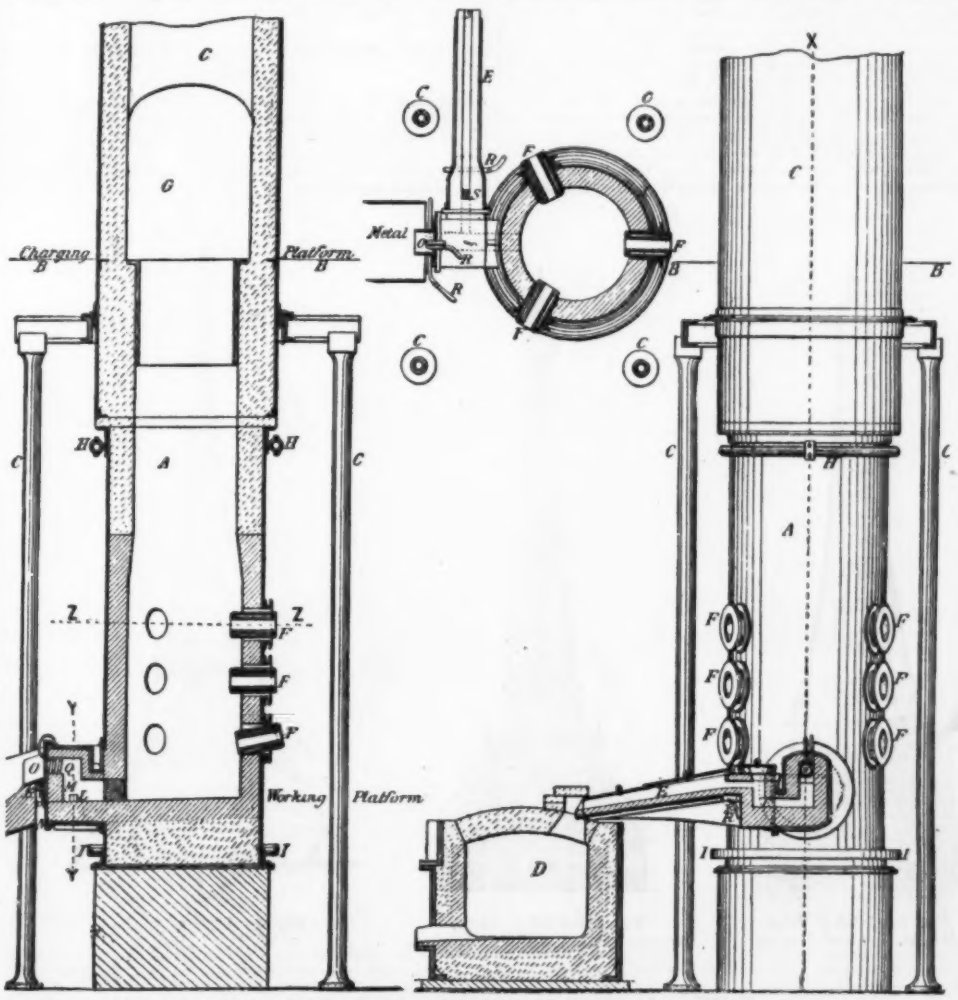
The tuyeres are arranged in several rows, to facilitate the melting of all the substances charged. They are arranged one above the other, so as to raise the temperature along a line passing in front of their nozzles, and so insure good working. They project inwardly, so that their ends may not get clogged by the colder and more decarburized matters which descend along the walls.

The approximation of the lower row of tuyeres to the hearth is intended to prolong the action of the blast upon the slag, which at that point is light and frothy, and upon the metal which flows down through it, so as to insure a greater elimination of phosphorus. The separation of metal from slag, as soon as both are removed from the action of the blast, is carried out so as to prevent the phosphorus already eliminated from going back into the metal, a result which would be produced by the reduction of the phosphoric acid of the slag by the action of the coke and the metal. Another object of the separation is to prevent too great a recarburization of the metal.

The temperature of the blast is as high as possible, viz., 400° at least, so as to insure the good action of the tuyeres. These would otherwise get clogged by the slag, which is always very refractory and stiff, or by the decarburized metal which forms at their ends.

The furnace being in operation, metallic iron is formed, by the action of the blast and the iron ore upon the cast iron or pig, on the bottom part of the walls, where it adheres, thus forming, after working twenty-four to thirty-six hours, a substitute for the original lining. The furnace may thus be run for an indefinite period of time. But it will be preferable after two or three months' working to reline the upper portion, as the bricks will then be worn out by attrition.

The production is from 50 to 75 tons per day of twenty-four hours. The product obtained usually has a white, spongy appearance. The slags are yellowish

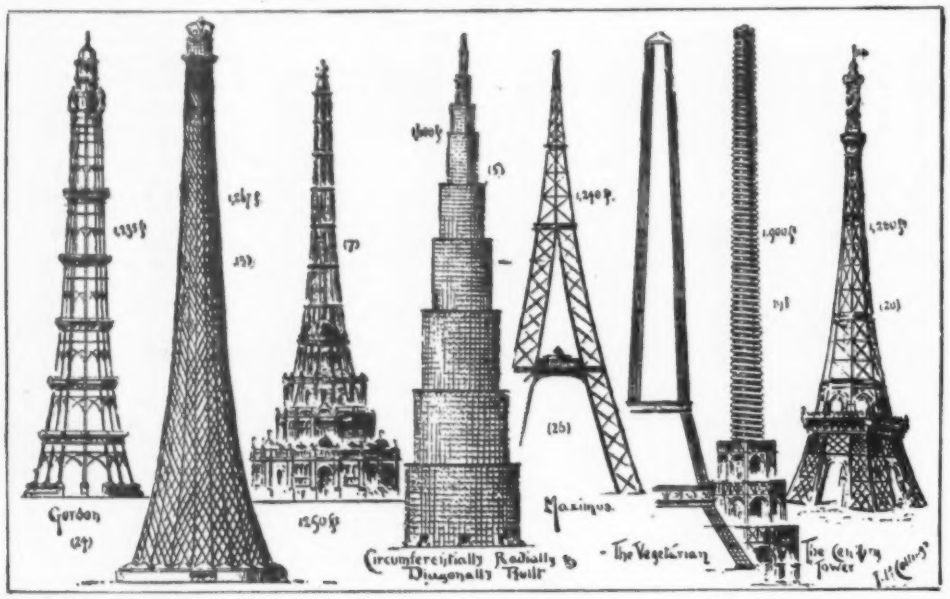


THE ROLLET PROCESS FOR CASTINGS.

white. They contain almost all the phosphorus eliminated from the cast iron or pig in the state of phosphoric acid and only a part of the sulphur in the condition of sulphide.

The elimination of the sulphur is complete up to 99 per cent., and even more. That of the phosphorus amounts to 80 or 85 per cent., in exceptional cases to 90 per cent., and more. And as the recarburizing action of the coke sets a limit to the decarburization of the cast iron, a casting once treated may be treated again in the same manner, by which means, beginning with any sort of castings, a carburized iron purer than the best Swedish iron used for cementation can be obtained.

The carburized iron thus obtained may be used in Siemens furnaces with acid bottoms, where it may be employed to a greater extent than cast iron or pig, and so diminish the weight, if wrought iron be required. It may be puddled, in order to produce iron destined for melting on acid bottoms, for crucible melting, or for cementation. It can also be used as cement steel for crucible melting, mixed with iron.



THE PROPOSED GREAT TOWER IN LONDON—SOME OF THE COMPETITIVE DESIGNS.

THE GREAT TOWER FOR LONDON.

IN reply to the invitation issued last November by the promoters of the great London tower, which is to outrival the Eiffel tower, eighty-six designs have been sent in. The promoters offered prizes of 500 guineas for the best and 250 guineas for the second best design and estimate for a tower of not less than 1,000 (afterward changed to 1,200) ft. in height. The specification was for a structure to resist wind pressure and sudden storms, and to be guarded against lightning. The material preferred was steel, but the designer is not confined to that or to any other material. The safety of the lifts was to be considered of the first importance, and the several stories of the tower were to be capable of bearing the weight of restaurants and offices. The date fixed for sending in the competitive designs was, on the application of engineers in the United States and Canada, extended from February 28 to March 14. The judges who are to decide upon the designs and estimates are: Sir Frederick Bramwell, Sir Benjamin Baker, Sir Edward Harland, Bart., M.P., Prof. A. B. W. Kennedy, and Messrs. C. Liddell, J. F. Moulton, and T. A. Walker, with Mr. E. H. Carbutt as their chairman.

We give illustrations of some of the designs. The first, No. 24 of the catalogue, is a tower with an octagonal skeleton, having a total height of 1,235 ft. The designer's signature is "Gordon." No. 13 is by T. V. Trew—a tower of 1,267 ft., with a base of 400 ft. diameter, to be constructed of steel. No. 7, by Kinkel and Pohl, of Washington, is also of steel, the height 1,260 ft., and the base 192 ft. in diameter. The skeleton has sixteen lattice legs and a central tube. No. 5 is submitted under the motto "Circumferentially, radially, and diagonally built," and is a tower of 1,600 ft. in height, designed so as to be completely taken to pieces, screw bolts being used instead of rivets, the columns being mainly of cast iron. No. 26 is by "Maximus," and is 1,240 ft. in height, the skeleton consisting of sixteen steel legs. The lower lifts of this tower are designed to be hydraulic, and the upper ones worked by compressed air. Next to this comes the "Vegetarian" tower, by Mr. Hills. The design is that of a gigantic steel obelisk, 2,007 ft. in height and 644 ft. square at the base. No. 19, "The Century Tower," is described simply as a steel tower, 1,900 ft. high, with Otis lifts. No. 20 (which reminds one of the Eiffel tower) is a design by Mr. T. C. Clarke, of New York, Professor Joseph Mayer, also of the United States, and Mr. W. Hildebrand, and is 1,280 ft. in height, with a base of 350 ft. square, the main skeleton being octagonal and the lower part of square form. The material is of steel throughout, and Otis lifts are to be used.—*London Daily Graphic.*

THE PROPOSED GREAT TOWER IN LONDON.

REFERRING to the exhibition of designs for the above tower, now being held in the hall of the Drapers' Company, Throgmorton Street, London, we show some of the more striking designs. In the following description the figures in brackets are the numbers in the official catalogue. Fig. 1 (No. 1) shows a design sent in by Mr. M. T. Otis, of Rochester, U. S. A., of a tower of 1,355 ft., with a base area of 400 ft. square. It is intended to be constructed of iron, and bolts are to be used in place of rivets. Fig. 2 (No. 7) is a steel tower 1,250 ft. high, with a base diameter of 192 ft. The framework consists essentially of sixteen lattice legs and a central tube. Messrs. Kinkel & Pohl, of Washington, U. S. A., are the desiguers. Fig. 3 (No. 8) represents a very light tower of steel 1,200 ft. high, in the form of a hexagonal skeleton braced around a cylindrical lift tube. Each of the feet is mounted on roller bearings. This design bears the initials W. P. Fig. 4 (No. 11) represents a tower of iron and steel 1,400 ft. high, standing on a base of 500 ft. square. It has four tubular columns and a central tube. Mr. E. S. Shaw, of Boston, Mass., U. S. A., is the designer. Fig. 5 (No. 20) is a design by Messrs. T. C. Clarke, Joseph Mayer, and W. Hildenbrand, of New York. This is a steel tower standing on a base area of 350 ft. square, and measuring 1,280 ft. in height. The skeleton is of octagonal form, but the lower part is square. Fig. 6 (No. 27) shows a design by Mr. P. Campanakis, of Constantinople, for a triangular tower 365 meters high. Fig. 7 (No. 28) is an imposing design for a steel tower 1,200 ft. high, of triangular skeleton form, and carrying a huge three-faced clock. The designer adopts the motto, "Time is Money."

Fig. 8 (No. 37) shows Messrs. A. D. Stewart, J. M. Maclaren, and W. Dunn's design for an octagonal tower of steel, 1,200 ft. high and 300 ft. in diameter at the base. Mr. Robert Wylie, of Liverpool, has designed a steel tower, Fig. 9 (No. 46), 1,470 ft. high, standing upon a masonry base of 8¼ acres. The framework is square at the lower extremity and octagonal above. Fig. 10 (No. 48) represents a design by Messrs. Ewen Harper, H. A. H. Harper, and John Graham, Birmingham. This tower is of slim appearance; it is 1,300 ft. high, and has a base of 400 ft. diameter. The skeleton consists of two equilateral triangles interlaced so as to form a hexagonal star. Messrs. Wyndham Vaughan and W. H. Tomkins, of 64 Broad Street Avenue, London, E. C., have sent in a design, Fig. 11 (No. 49), for a steel tower 1,500 ft. high, with a base 500 ft. diameter. The frame is of octagonal form, and consists of eight triangular columns, each of which is composed of three steel tubes with lattice bracing.

Fig. 12 (No. 50) shows a handsome Gothic design by Mr. Max am Ende, of 5 Victoria Street, London, S. W. It is 1,550 ft. high, and is made entirely of steel. The principal platform is situated 1,000 ft. above the ground, and the lifts are situated in each of the four main columns. The design Fig. 13 (No. 51), sent in by Messrs. J. J. Webster & J. W. Haigh, of Liverpool, is for an octagonal steel tower 1,300 ft. high, standing on a base 470 ft. diameter, and shows ample building and platform spaces. Fig. 14 (No. 53) shows a design by Messrs. Francis Fox and George E. Grayson, of a steel tower 1,300 ft. high, covering a floor space 370 ft. in diameter. The skeleton consists of a double octagonal frame of sixteen lattice columns, each 20 ft. square. Mr. J. Sinclair Fairfax, of 433 Strand, London, W. C., has designed a square steel tower, 1,296 ft. high and 576 ft. diameter at the base. This is shown in Fig. 15 (No. 54).

The design shown in Fig. 16 (No. 55) is by Mr. Henry Davey, 3 Princes Street, Westminster. It is for a hexagonal steel tower 1,250 ft. The skeleton framing consists of twelve steel columns, braced in the form of a truncated cone, on the top of which is a lighthouse tower and lamp, with central staircase. Fig. 17 (No. 57) shows a design for a steel tower 1,250 ft. high, having a square frame to the upper platform, and an octagonal spire above, by Messrs. R. J. G. Read & L. A. Shuffrey, 38 Welbeck Street, London, W. The design shown in Fig. 18 (No. 59) is for a "tripod tower" 1,400 ft. high, the arms being hollow tapered steel tubes 30 ft. in diameter at their bases. Their centers are 350 ft. apart. It is intended to place the lifts in these tubes. Professor R. H. Smith and Mr. W. Henman are the designers. Fig. 19 (No. 60) shows a design by Mr. H. E. Sketchley, of 5 Gwendwr Road, West Kensington, for a steel tower 1,193 ft. high, the upper portion of which is described

Fig. 1.—1,355 ft. high.
Mr. M. T. Otis' Design.

Fig. 2.—1,250 ft. high.
Messrs. Kinkel & Pohl's Design.

Fig. 3.—1,200 ft. high.
"W. P.'s" Design.

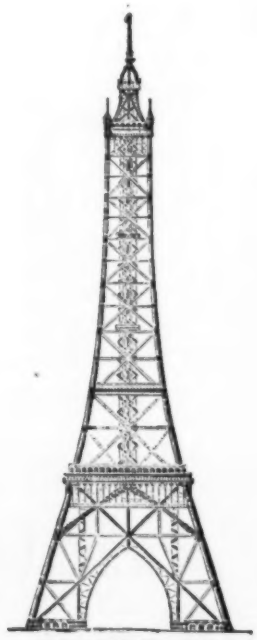


Fig. 4.—1,400 ft. high.
Mr. E. S. Shaw's Design

Fig. 5.—1,280 ft. high.
Messrs. T. C. Clarke, J. Mayer, and W. Hildenbrand's Design.

A FEW OF THE DESIGNS FOR THE PROPOSED GREAT TOWER IN LONDON.

Fig. 6.—365 meters high.
Mr. P. Campanakis' Design.

Fig. 7.—1,200 ft. high.
"Time is Money's" Design.

Fig. 8.—1,200 ft. high.
Messrs. A. D. Stewart, J. M. Maclaren, and W. Dunn's Design.

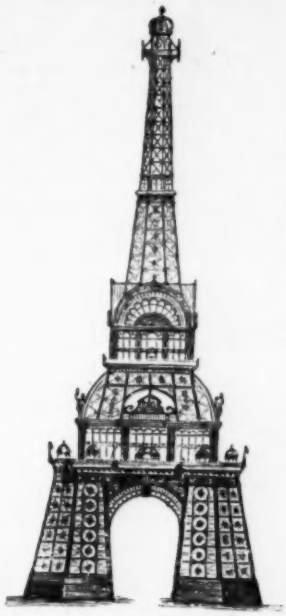


Fig. 9.—1,470 ft. high.
Mr. Robert Wylie's Design.

Fig. 10.—1,300 ft. high.
Messrs. E. Harper, H. A. H. Harper, and J. Graham's Design.

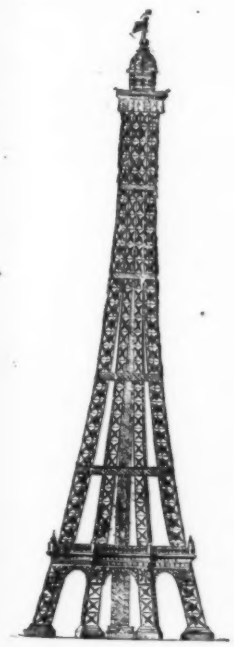


Fig. 11.—1,500 ft. high.
Messrs. Wyndham Vaughan and W. H. Tomkins' Design.

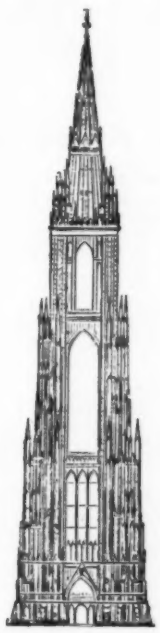


Fig. 12.—1,550 ft. high.
Mr. Max am Ende's Design.

Fig. 13.—1,300 ft. high.
Messrs. J. J. Webster and J. W. Haigh's Design.

Fig. 14.—1,300 ft. high.
Messrs. F. Fox and G. E. Grayson's Design.

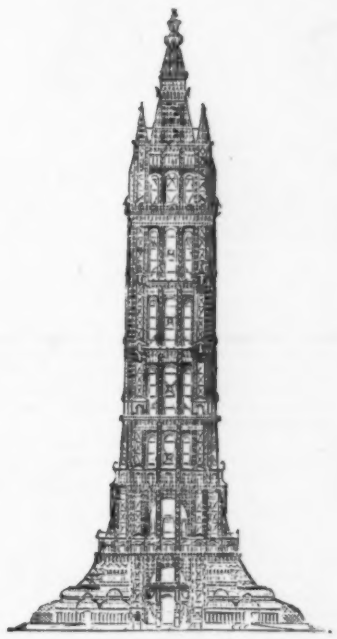


Fig 15.—1,296 ft. high.
Mr. S. J. Fairfax's Design.

Fig. 16.—1,250 ft. high.
Mr. H. Davey's Design.

Fig. 17.—1,250 ft. high.
Messrs. R. J. G. Read and L. A. Shuffrey's Design.

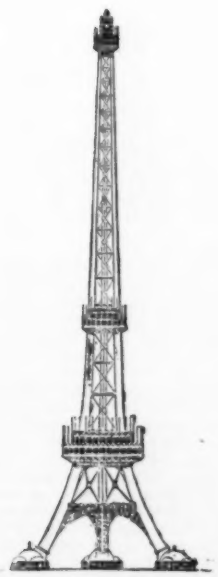


Fig. 18.—1,400 ft. high.
Prof. R. H. Smith and Mr. W. Henman's Design.

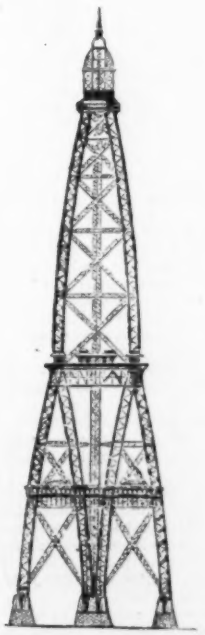


Fig. 19 —1,193 ft. high.
Mr. H. E. Sketchley's Design.

Fig. 20.—440 meters high.
Mr. Lamont Young's Design.

A FEW OF THE DESIGNS FOR THE PROPOSED GREAT TOWER IN LONDON.

as "equivalent to an independent tower resting upon four separate lower towers." Fig. 20 (No. 64) is a design by Mr. Lamont Young, of Villa Lucia, Naples, and is made up of a group of five towers, the main central one being 440 meters high, and supporting a large terrestrial globe, and four secondary ones. Fig. 21 (No. 72), below, shows a sketch of a design sent from Adelaide, Australia, which we scarcely need say was inadmissible for competition. The designer recommends it "for obviating the terrors of sickness on the Channel passage until such time as the channel tunnel may have become an accomplished fact." The vehicle, he says, "can be towed across the channel from one shore to the other by means of a cable attached to a steamer with great facility. It would be an enormous attraction, for fear of sea sickness and the novelty of the thing would combine to make it the talk of the

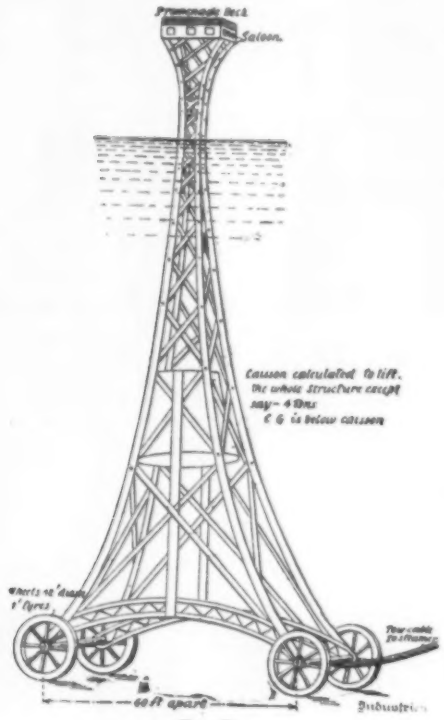


FIG. 21.

day." There are other curious designs sent in which might well become "the talk of the day," but we have neither space nor desire to deal with them. As the adjudication of the committee has not yet been made known, it would be invidious to make any comment on the designs.—*Industries.*

THE CHEMIN DE FER GLISSANT OR SLIDING RAILWAY.*

By Sir DOUGLAS GALTON, K.C.B., D.C.L., F.R.S.

THE original design of this form of railway is due to M. Girard, whose name is well known as that of a hydraulic engineer of considerable eminence. Girard was, moreover, an enthusiastic inventor, and the first idea of a railway on which a new mode of propulsion might be given to the trains occurred to him nearly forty years ago. At that time the hydraulic engineering works of La Jonchere were flourishing under M. Girard's management and ownership, and he was engaged upon constructing and erecting the turbines of the now famous chocolate factory of M. Menier at Noisiel. M. Girard proposed to substitute for locomotive engines on a railway a series of jets of water issuing from nozzles standing up along the center of the railway track, so arranged that the issuing streams could exert their effect on the under side of the carriages composing the train, and cause it to travel along the rails.

He further proposed to suppress the wheels, and to substitute flat surfaces or bearing plates, upon which the carriages would rest; these would slide upon rails of a section specially designed to support them, and in order to reduce the friction, M. Girard proposed to separate the surface of the rail from that of the bearer by means of a film of water to be maintained between the bearing plates and the rails.

An experimental length of line which he constructed at La Jonchere, on which there was an incline of 1 in 20, led him to some interesting conclusions, and he was further encouraged by the great interest which the late Emperor Napoleon III. showed in his scheme.

M. Girard considered that the results which he had obtained would justify the application of the system in special cases on a paying basis, and he applied for a concession for a railway from Calais to Marseilles, which was granted to him in 1869, and to this concession a subvention was attached.

But the war of 1870 put a stop to the whole matter, and further resulted in the destruction by the German army of M. Girard's model railway, and in his death on the battle field early in 1871.

After peace was restored, what remained of M. Girard's works at La Jonchere was sold. Among the relics were all the documents relating to the railway scheme, and these were finally purchased by M. A. Barre, who had worked with M. Girard, and a model of the line on a small scale was submitted to the jury on railways of the Paris exhibition of 1878.

For several years M. Barre has been engaged in making further experiments upon, and gradually changing and developing, the original ideas of M. Girard.

A line of 170 yards long on the improved system was established in the late Paris exhibition. This line had first a downward incline of 1 in 90 for 40 yards, followed by a level of nearly 90 yards, and then an upward incline of about 40 yards at an incline of 1 in 180. Trains were run daily upon this line, but as its length was only sufficient to enable a train to be run backward and forward, none of those arrangements could be exhibited upon it which would be necessary in the general working of a railway with consecutive stations, or for transferring a train from one line to another.

The design may be classed under two heads:

First, the arrangements for supporting the vehicles. These consist of (1st) the bearer or skate affixed to the vehicle; (2d) the method of supplying the film of water to the bearer or skate; (3d) the rail.

Secondly, the method of propulsion intended to supersede the ordinary methods of traction. This consists of (4th) the arrangements on the vehicle for receiving the water of propulsion; (5th) the hydrants for propulsion; (6th) the arrangements for catching the water after it has served its purpose.

The diagrams which illustrate this paper have been supplied by the courtesy of the editor of *Engineering.*

I.—ARRANGEMENTS FOR SUPPORTING THE VEHICLES.

(1.) *The Bearer or Skate or Slide.*—Of these there are four to six attached to each carriage, corresponding in position to the wheels in an ordinary railway carriage.

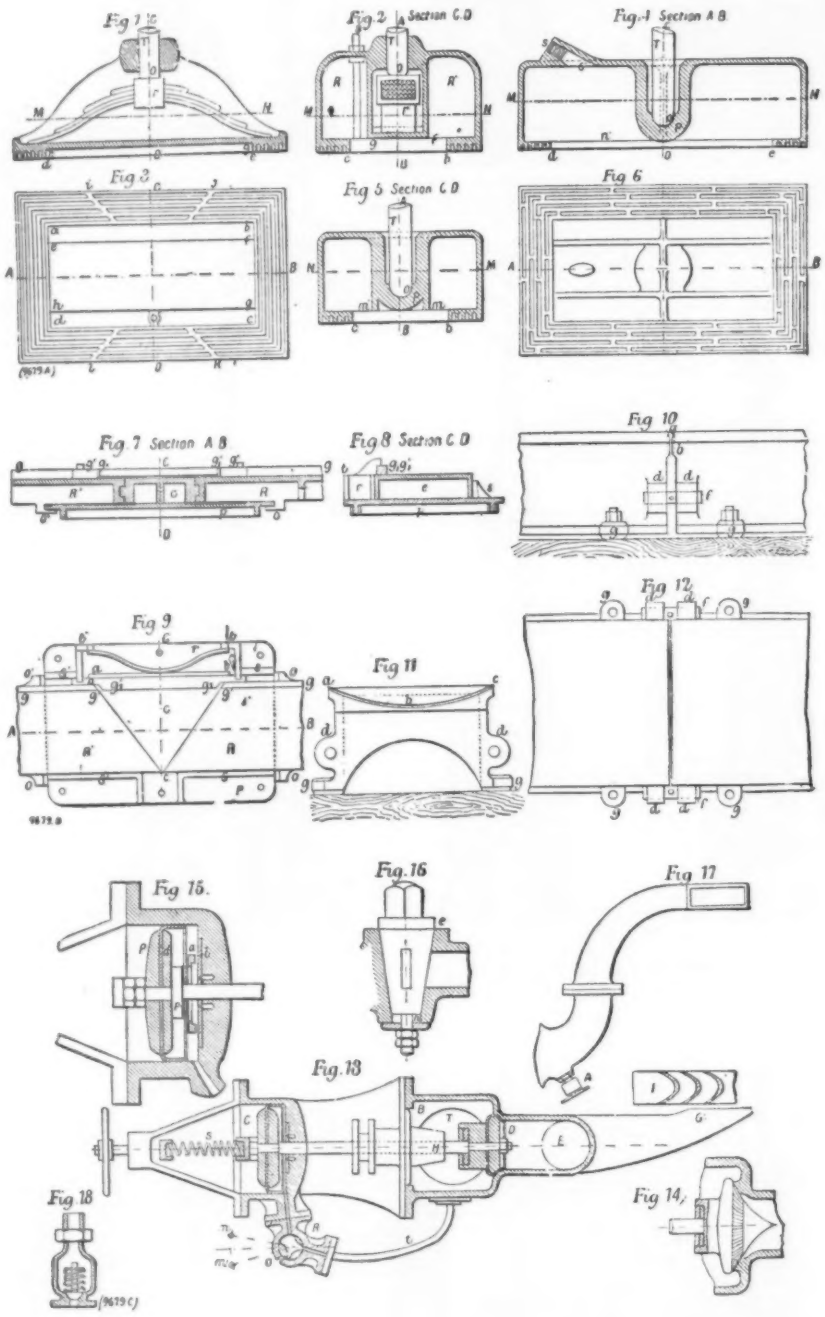
M. Girard's original proposal for these is shown in Figs. 1, 2, 3. This has been altered by M. Barre, and his revised arrangement is shown in Figs. 4, 5, 6.

The bottom of the skate is rectangular, 22 cm. wide by 44 cm. long (say 8¾ inches by 17½ inches), that is to say, it covers a total area of 968 square centimeters, or about 150 square inches. It is, however, grooved or indented, so that the actual surface resting on the rail when the skate is at rest does not exceed about 84 square inches; but of course when water under pressure is admitted, and the skate raised to allow of its resting on a film of water, a considerable portion of the area of the skate is utilized to support the carriage.

The skates are made of cast iron. They consist of a box with a central depression or hole rounded at its lower part, in which the rounded end of a rod (marked T in Figs. 4 and 5) which supports the carriage rests.

The depression which supports the rod descends to within 5 mm. (about ¼ inch) from the surface of the rail, and the bottom of the rod is thus not more than one inch from the rail; the form of the upper part of the depression allows the rod a play of 7 or 8 mm. (say ¼ inch) all round. This mode of attachment gives a certain freedom of play between the carriage attachment and the slide, which allows the slide to accommodate itself to inequalities in the road. Hence it is not necessary for the rails to be absolutely on the same horizontal plane in order that the skate should rest on the film of water, and thus M. Barre contends that the rails do not require more attention in maintenance than those of the ordinary railway. The box is closed at the top and open at the bottom, but it has a broad grooved rim all round, which forms the bearing surface which rests on the rail.

(2.) *Method of Supplying Water to the Skate.*—Water is admitted to this box through the aperture S, Fig. 4, and is retained by the pressure of the grooved rim upon the rail. The grooves in this bearing surface are arranged as shown in Fig. 6, communication between these being established by passages which are not directly opposite each other. The water which is admitted to slide through the openings, S, as it flows downward, can only escape by traversing the grooves in the bearing surface; the passages between these grooves are not opposite each other, hence the velocity of the water in its progress along the grooves is decreased, and thus waste of water is checked. When the normal pressure is exerted by the water between the rail and the slide, a film of water from one-half to three-quarters of a millimeter in thickness between the surfaces is maintained.



M. Barre states that he made an experiment at Senlis on a skate in the shape of a rectangle 440 mm. long and 220 mm. wide. The weight borne, including the weight of the skate, was 1,000 kg. The pressure in the reservoir, maintained by compressed air, showed a variation of from 3 to 2 kilog. per cm., but the pressure measured under the skate remained constant at 1·8 kilog.

M. Barre assumes from this experiment that, as the weight actually borne by the skate was 1,060 kilog., the portion of the total surface of the skates actively employed in supporting this weight was only 558 cm. (about 90 square inches), which corresponds to a rectangle 377 × 157 mm., and that the perimeter of this rectangle multiplied by the depth of the film of water formed the orifice through which the water passed. He states that the escape of water theoretically due to the pressure of 1·8 kilog. through this aperture would have been 15·117 liters per second; but apparently, owing to the resistance to the flow of water occasioned by the grooves, the actual discharge was only 0·967

* A paper recently read before the Society of Arts, London.

liters per second. The experiments made on the railway in the Paris exhibition are stated to have corroborated these earlier experiments.

As regards the weight on the skates in a train, M. Barre assumes his passenger carriages to be light, and to weigh only 3½ tons each; assuming that the average weight of fifty passengers would about equal this weight, and that the loaded vehicle would be borne on six skates, then each skate of the dimensions mentioned would have to support a pressure of about 20 lb. per square inch over the whole surface, or a pressure of nearly 30 lb. per square inch over the portion which M. Barre mentions above as being actively employed in supporting the weight.

M. Barre states that he has, moreover, devised an arrangement by which the amount of water consumed by the skates is proportional to the weight upon them; but as this has not yet been completely secured by patent, it cannot be described here.

It is stated that for short runs, up to about a mile, water at a sufficient pressure can be obtained by carrying on the tender reservoirs of water charged under pressure, these reservoirs being recharged at each station. For longer journeys, M. Barre first proposed to carry a boiler, with engine and pump for compressing the water; in which case the reservoirs would be placed on a tender, and would have to be of considerable capacity, on account of the relatively large amount of water consumed; these reservoirs would be kept filled, while the train is in motion, from the waste water channel in the permanent way, by means of the ordinary water scoop.

M. Barre, however, states that he has now devised a method for supplying the water required for the skates under the several carriages, by passing a part of the superelevation of the outer rail would prevent friction against these guides, as the method of propulsion of the trains would cause all the trains to move at a nearly similar speed, to which the superelevation of the rail would be adapted.

II.—METHODS OF PROPULSION OF THE TRAIN.

(4.) *Arrangements on the Vehicles for Receiving an Impulse from the Water of Propulsion.*—Under each carriage is placed a series of vanes arranged longitudinally, as shown in the sketch. (I, Fig. 13.) From each series of vanes a pin projects. As the carriage approaches each of the hydrants consecutively, this pin opens a cock and allows the water from that hydrant to flow out and act upon the vanes to force forward the carriage; a second pin closes the cock as soon as the series of vanes has passed the hydrant.

(5.) *Hydrants for Propulsion.*—The water which acts on the vanes fixed on the carriages is supplied from a main running the whole length of the line, from which it rises through hydrants (Figs. 15–17) which, as before mentioned, are opened by the mechanism on the train. The main is supplied with water by pumps placed at intervals, and connected with cisterns under pressure; the water used in propelling the train, as well as the water from the skates, falls into a waste water channel in the permanent way, from which it is returned to the cisterns by the pumps.

The hydrants may be generally described as follows: They consist of three parts; these parts are a valve chamber, a cylinder, and an automatic controlling valve (Fig. 13).

The water under pressure, which is to be used for propelling the train, flows from the main up the standpipe, T, which is placed in the center line of the permanent way, and into the valve chamber; in this chamber the valve, D, closes the entrance to the nozzle, E, the pressure of the water at the back of this valve keeping it firmly shut. The valve is opened by means of the spindle attached to it, and which passes through a stuffing box, H, to a leather packed piston in the cylinder, C. The diameter of this piston is larger than that of the valve, D. The part of the cylinder, C, which is in front of the piston is in communication with the valve chamber by means of the pipe, *t*, and the three-way cock, R; one of the openings in this valve, through which the water passes into the cylinder, is much larger than the two others, in order that this passage may not be obstructed.

The water under pressure is delivered to the cylinder, C, in front of the piston, the force exerted being sufficient to drive back the piston and thus to withdraw the valve, D, from its seat; this allows the water to rush from the standpipe and valve chamber through the nozzle against the row of vanes or pallets, I, beneath the carriage.

The cock, R, is opened by means of levers placed under the tender, and while open it keeps the back valve, D, from its seat and allows the water to escape through the nozzle, E, until the impulse has been completed. A corresponding lever at the other end of the train closes the cock, and stops the jet, until it is opened for a new impulse. It is necessary to have a double set of such levers on the train in order to operate upon the two series of nozzles which are required for driving the train in opposite directions.

The spring, S, assists in throwing back the piston to its normal position when the water is cut off from cylinder, C, and the pipe from the cylinder is then put into communication with the atmosphere through the small opening, O, that serves as a sort of hydraulic brake when the valve, D, returns to its seat.

Fig. 17 illustrates the form of nozzle employed; the valve, A, which is introduced near the bottom, allows the nozzle to be emptied. The arrangement of this valve is shown in Fig. 18, where it will be seen that it is kept open by a spiral spring, except when the water under pressure passes into the nozzle and forces the valve down; but as soon as this pressure is removed, the valve opens and allows the contents of the nozzle to escape.

The distance apart of the hydrants depends on the length of the train. At the Paris exhibition, the train was a little over 50 feet long, consequently the hydrants had to be placed at intervals of about 48 feet; but if the train had been 180 feet long, the hydrants might have been 120 feet apart.

The hydrants at the Paris exhibition discharged 105 liters (about 22 gallons) per second under a pressure of 10 kilog. (about 140 lb. per square inch). This gave a propelling force of 450 kilog. With more powerful apparatus, or a waterfall, 1,000 kilog. of propelling force could be obtained, or the number of hydrants may be multiplied. Thus, with a propelling force of the latter amount, and with four hydrants instead of one, the propelling power would be 4,000 kilog. The water is used over again, and, in fact, it acts only as a lever would.

As regards the speed, a turbine will attain 80 per cent. of the speed attained by the flow of the water, and with a pressure of 10 kilog. per square centimeter, the speed at which the water would pass out of the hydrant would be 44 meters per second.

M. Barre assumes that 80 per cent. of this velocity would be utilized, and that, with that pressure, the train might consequently travel at 120 kilometers, or nearly 70 miles, per hour.

(6.) *Arrangement for Catching the Water after it has Served its Purpose of Propulsion.*—An enormous amount of water is projected from the nozzles, which is collected in a suitable channel made in the bed of the permanent way, to be brought back to a pumping station.

The spread of the water, after it has acted on the vanes, is checked and directed into the conduit by means of a special arrangement, which is shown in Figs. 23 and 24. P is the mouth of the nozzle, E the line of pallets beneath the carriage, and the structure, A B C D, is a curved apron placed on each side of the pallets and attached to the roadbed; as the line of pallets passes between the nozzle of the hydrant and the apron, the water is thrown to the right and left into the collector, the curved plates, *t*, t^1, t^2, acting to divert it, while its force is further broken by means of the row of chains suspended from the top of the curve, as shown in the sketch.

The foregoing are the principal special details of the system, but there are a number of minor devices to overcome obvious difficulties connected with working.

In the event of a train being stopped by a signal, assuming that a nozzle beneath one or more of the carriages has been opened and continues to discharge a jet of water against the pallets beneath the carriage, two operations would be necessary, that of closing the valve immediately to prevent waste of water so long as the train remains standing, and of opening it again when the signal against the train is removed. The arrangement adopted to meet this contingency is shown in Fig. 19. A and A_1 indicate the extreme positions of the valves connected with the nozzles of the line of standpipes. Outside these, and running along the whole length of the train, are two iron tubes, B and B^1, suspended from the arms, C C^1, which are mounted on the shaft, E, which also runs along the whole length of the train, suitable couplings in all cases being provided between the carriages. Secured to the central cross frame under each carriage is the cylinder, H, with its piston rod, G, connected to the shaft, E, by means of a crank with a slotted hole and pin; openings are made at each end of the cylinder, H, connected by means of the pipes, I and I_1, to other pipes, R R_1, which also extend throughout the train, terminating at the tender. The rod, K, passing through bearings, P P^1, in the bracket, N, carries midway of its length, between the bearings, a disk, against which press the spiral springs, M M^1; according to the movement imparted to the piston, so is the spring, M or M^1, compressed. One end of each of the pipes, R R^1, terminates on the tender in a small receiver, and the whole system is filled with glycerine; the upper part of each receiver is in communication with a small reservoir charged with compressed air, the connection being controlled by means of a tap. The normal position of each of these taps places the receivers in communication with the air; but if either of them is turned, a passage is opened to the compressed air chamber, and the piston, H, is set in movement to the right or left, together with the whole system of the shaft, E, and the rods, B and B^1, which in their movement open or close the valves of the nozzle. By the movement of the piston, H, the glycerine contained in that part of the system not under pressure is caused to rise in the receiver, and the spring, M or M^1, is compressed. After this operation is performed, if the tap is again turned to its normal position, the piston, H, returns to the middle of the cylinder as soon as the compressed air escapes, the action of the spring and the difference of level of the glycerine in the two receivers being sufficient to overcome the weight of the different parts. This mechanism can be controlled from both ends of the train either to open or close the valves connected with each line of nozzles.

When a train is in motion, the jets upon which it depends for its speed are opened or closed automatically by the special mechanism placed at each end of the train, as already explained; four of these devices are, therefore, necessary, two for controlling the series of nozzles which propel the train in one direction, and the other two for actuating those which send the train in the opposite direction. The diagrams, Figs. 20 to 22, give an idea of the arrangement adopted for this purpose; the arm that operates the valve of the nozzle has a parabolic working face, against which the lever of the valve comes in contact, the movement of the train causing the arm to pass over it gradually, without any shock, and forcing the valve lever to take the necessary position. The corresponding arm at the end of the train is arranged so as to give a reverse movement,

Fig. 19

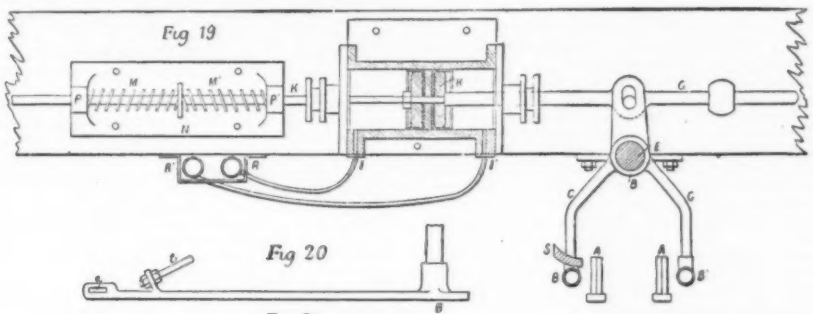


Fig. 20

Fig. 21

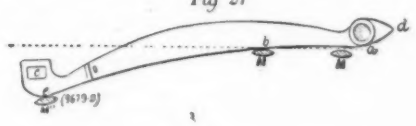


Fig. 22

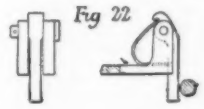


Fig. 23

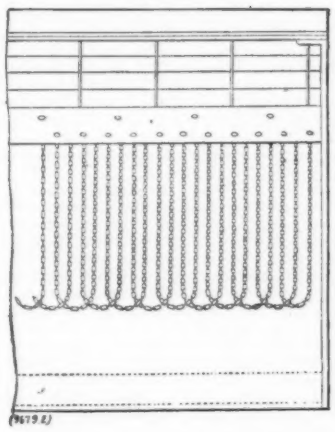
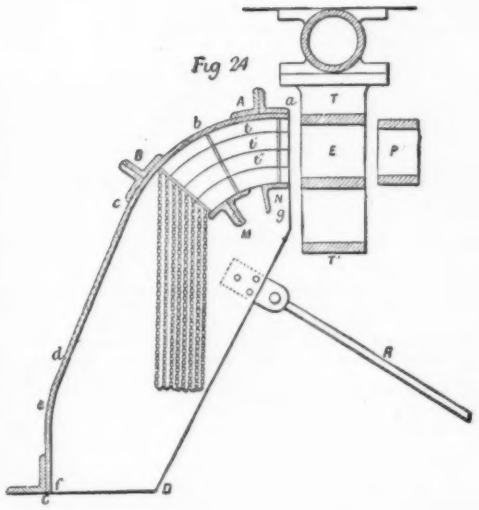


Fig. 24



water from the hydrants directly into a reservoir placed in each carriage, under the necessary pressure, and in a sufficient quantity to supply the skates for about forty seconds. In this arrangement the turbines under each carriage would have to be shortened to allow space for the water to pass to the reservoir; this plan would therefore be only applicable for long journeys, because in the case of frequent stops and starts the whole force of the water is required for propulsion. The particulars of this arrangement have not been furnished.

It is to be observed that the expenditure of water for the skates is per second and not per mile; consequently the faster the train goes, the less water per mile is consumed.

(3.) *The Rail.*—The rail is of iron; it presents a broad, flat, and perfectly true surface, not liable to be interrupted at any point, and which, at the same time, is free to expand or contract. An extremely ingenious plan for securing this object was proposed by M. Girard, and is shown in Figs. 7, 8, 9. This was, however, found too complicated in practice, and M. Barre has adopted a simpler and equally efficient arrangement.

This method of joining the rails is shown in Figs. 10, 11, 12. A curved groove, *a b c*, is made at the end of each rail, and in this groove is placed a rubber fillet, which has sufficient elasticity to allow for the variations in length of the rail arising from differences of temperature; the rails are secured together by the bolts, *f*, passing through the flanges, *d*; *g g* are holding-down bolts, securing the permanent way to the substructure. On the outer side of each rail a guard plate, not shown in the sketch, can be attached, if desired, to serve as a guide for the slides. On curves the

bringing the lever of the valve back to its original position, and thus shutting off the jet of water. This brief description will, it is hoped, enable the general arrangements of the system to be understood.

Between the 12th July, 1889, and the 6th November, that is in 114 days, there were carried 118,000 passengers on the short line at the exhibition. The total length traversed by the train was 1,200 kilometers, or 750 miles. The propellers were opened 4,000 times, and closed 4,000 times, and they acted as well on the last day as they did on the first day. At the end of the time the automatic valves did not exhibit the slightest wear or difficulty of working. The rails and the skates were equally free from any appearance of wear; in fact, no repairs of any kind were needed from the opening till the closing of the line.

It is necessary now to consider the question of working. In the first place, the character of the train differs essentially from that on an ordinary railway. The first-class carriages, each containing 50 passengers, are proposed to weigh from 3,000 to 3,500 kilog., say three to four tons, that is to say, about 160 pounds per passenger. The ordinary railway carriage may be said to weigh anything from 300 pounds per passenger upward.

This great reduction of weight is, it is supposed, made on the assumption that the shocks to the vehicles on such a railway will be very slight compared with those on a railway whose carriages are connected with spring buffers and drawbars, and propelled by locomotive engines, for in an ordinary train the locomotive engine with its tender not only contributes a very considerable amount of dead weight, but being attached to the train, its action upon the vehicles in propelling the train and in rapid stops occasionally causes shocks; these shocks are indeed almost necessarily incidental to propulsion by means of a locomotive engine, and render it imperative to provide much strength and consequent weight in the carriages.

The heaviest vehicle on the sliding railway is the one employed to carry both the conductor and the water for the skates, the weight of which is not assumed to exceed 8,000 kilog., say 8 tons.

Then again M. Barre proposes to take steps to reduce the resistance from the air at high speeds. This resistance acts in an ordinary train not only on the front of the train, but against the front of each vehicle in a train, dependent upon the intervals between the vehicles.

M. Barre proposes to make the train continuous, in the shape of the half of a cigar divided longitudinally, articulated so as to allow of its passing round curves, and with pointed ends, and he urges that side winds would have less effect on this train than on an ordinary train, in consequence of the less height it would stand above the rails, and of the curved top. Moreover, it is argued that the resistance arising from the flanges of the wheels being pressed against the rails in a strong side wind would not be so great a cause of retardation in M. Barre's as in an ordinary railway.

The following calculations as to the working have been supplied by M. Barre, and must be taken on his responsibility, as I have had no opportunity of verifying or checking them. In stating them it will therefore be more convenient to retain the metric numeration.

The work of compression required to maintain a film of water between the bearer or skate and the rail during the progress of the train, as compared with the economy resulting from the diminished resistance due to the sliding motion, is given by M. Barre as follows: Assume a train of four carriages, each containing 50 passengers, or 200 passengers in all. With the sliding system on a short railway the train would have a tender carrying the necessary supply of water, and the weight of the train would be made up as follows:

	Tons.
Four carriages, dead weight, 3½ tons each..	14
Two hundred passengers, say.....	14
Two tenders, 6 tons each.....	12
	40

Assume the train of six vehicles to be supported on 36 bearers or skates of 22 cm. × 44 cm. Now according to the experiments made on the line at the French exhibition, each of these would require nearly 1 liter (or 1·76 pints) of water per second as a maximum. Thus the total consumption of water in the train for this purpose would be 36 liters (or 7 92 gallons) per second.

These 36 liters might, in the case of frequent stoppages, be taken in from the principal water main, which is maintained at a pressure of 10 kilogrammes per square centimeter, or 144 lb. per square inch, which is equivalent to a column of water of 100 meters in height.

This pressure is far in excess of the pressure actually necessary to produce a film of water sufficient to carry the skates. But upon this supposition the work absorbed per second to maintain the sliding of the train would thus be 36 kilogrammeters × 100 meters = 3,600 kilogrammeters, or 48 horse power.

If the train, which weighs 40 tons, slides at the rate of 20 meters per second—that is 72 kilometers, or nearly 45 miles per hour—the resistance to the sliding, as gathered from the experiments which have been made on the model railway at the exhibition, is 1 kilog. (= 2·2 lb.) per ton as a maximum; so that the total resistance of the train would be 40 kilog., which multiplied by 20 meters per second gives 800 kilogrammeters, or 10·66 horse power. Hence the work to be done in sliding and traction, or propulsion, would be 48 + 10·66 horse power, or 58·66 horse power.

The work done in the propulsion of the train would be effected by the water which flowed through the nozzles; and this water, during its action on the train, would not be confined as if it were driving a piston, but it would be acting in the open air, consequently more water would be required to produce the work on the train than the amount which theory would show to be sufficient to effect the work, if acting under a given head in a confined space.

From the conditions of the working at the Paris exhibition, it may have been difficult to ascertain the actual quantity of water used in proportion to the work done in propelling the train.

M. Barre states that his observations show that from 75 per cent. to 50 per cent. of the water is utilized by the turbine under the carriages, and on the other hand he contends that the consumption of fuel in the locomotive of any ordinary railway would be nearly double that which would be necessary for the proposed fixed pumping engines, because of the regularity of working of these latter; and that as the water is not wasted, but is pumped back, and only coal is consumed, it is fair for purposes of comparison only to take into account the horse power shown to be required by calculation.

Assuming, however, that 50 per cent. of the water only is utilized, and that the quantity of water incidental to the propulsion would be double the amount theoretically required, this would bring up the combined horse power for sliding and for traction to at least 70 horse power.

To compare this with an ordinary railway, we will assume a train composed of corresponding elements, but in which the carriages would necessarily be heavier, viz.:

	Tons.
4 carriages weighing 6,500 kils., or say.....	26
200 passengers averaging 70 kils. each, say...	14
1 locomotive with tender, say	40
Total..... 80	

This weight of 40 tons for the locomotive and tender is not excessive, if a speed of 45 miles per hour is to be assumed on a railway similar to the one under consideration, with many stops, because a powerful engine is required for rapidity in starting and stopping.

The resistances to this train are assumed by M. Barre as follows:

	Kils.
For the locomotive at 8 kils. per ton.....	320
" " carriages at 4 kil. = 8 lb.....	160
	480

Upon this calculation the work to be done in propelling the train on an ordinary railway would be 480 kil. × 20_m = 9,600 kil. = 128 horse power.

Thus, even in the unfavorable case of the sliding railway being worked with frequent stops, and taking the water for supplying the skates from the principal water main at considerably more than double the pressure actually required, there would be a considerable economy in the traction on this system, as the tractive force to be exerted in moving the sliding train would only be between one-half and two-thirds of that upon an ordinary railway with wheeled carriages and a locomotive.

The exact arrangements under which the trains are to be run on the line at Neasden have not yet been made public, but M. Barre gives the following general calculations, which show similarly the economy in working which would result from the adoption of the system upon a larger scale.

He assumes a train composed of 20 carriages, each carried on six skates, and a tender supported on 12 skates, which would carry a steam pump for providing the necessary pressure for the water for the skates. This water would be taken up by an ordinary water scoop from the channel in the center of the line, which receives the water discharged by the hydrants in propelling the train. It would therefore be at the atmospheric pressure, and it would require to be compressed by the engine and pumps on the tender; but 2½ kilog. per cm., equivalent to about 35 pounds to the square inch of compression, would suffice in this case, because according to experiments made by a pressure gauge on skates of similar dimension, it was found that 1·8 kilog. under the skates (which is equivalent to between 25 pounds and 26 pounds per square inch) was sufficient to support them on a film of water. The compression to 2½ kilog. would represent a column of water of 25 meters in height.

The number of skates in the train would be 132, and the water required for their supply would thus be 132 liters per second.

M. Barre proposes to put pressure on this water by means of a pump running at a very high velocity, and therefore of a relatively small weight. The work done for the compression would be 132 kilog. × 25 meters = 3,300 kilogrammeters, or 44 horse power. The total weight of the train would be made up as follows:

	Tons.
20 carriages, weighing each 3,500 kilog.....	70
1,000 passengers, at an average of 70 kilog..	70
1 tender, weighing.....	12
Total.... ... ., ...	152

If we assume the train to travel as before, at 20 meters per second (equivalent to 45 miles per hour), and if we assume the resistance of the slides to be that shown by the experiments, viz., 1 kilog. per ton, the work done in propulsion will be 152 kilog. × 20^m = 3,040 kilog., or somewhat over 40 horse power.

Hence the work done in sliding and propulsion of these trains running long distances will be 44 + 40 = 84 horse power on the level; and assuming, as before, that the water which was ejected from the nozzle during the passage of the train was double that actually required for doing the work, if applied in a confined space, the sliding train would absorb say 124 horse power.

A train conveying a similar number of passengers, on wheels, and drawn by a locomotive, would be made up as follows:

	Tons.	
20 carriages with dead weight of 6½ tons....	= 130	
1,000 passengers at the average of 70 kilog. each.....	= 70	— 200
1 locomotive.....	45	
1 tender.....	15	— 60
		260

The resistance of the train may be considered to be as follows, viz., 4 kilogrammes for the carriages and double that for the engine and tender. Thus:

	Kilog.
The carriages and the passengers, weighing 200 tons, at 4 kilogrammes per ton	= 800
The locomotive and tender weighing 60 tons, at say 8 kilogrammes per ton	= 480
Total.....	1,280

Assuming the same speed as before, viz., 20 meters per second, or 45 miles per hour, 1,280 kilog. × 20 meters = 25,600 kilogrammeters, or 340 horse power. Thus the tractive power required to draw the train on a long distance railway would be considerably less than one-half of that required for a train on wheels with a locomotive.

Of course, the effect of inclines would be favorable to the sliding railway, in that the dead weight of the train in proportion to the effective load of passengers would be smaller. But, of course, the hydrants would have to be placed at nearer intervals in proportion to the steepness of the incline.

It is further alleged that there would, moreover, be economy in wear and tear of carriages and wagons arising from the absence of shocks and vibration which occur on ordinary railways, as well as the further saving in maintenance arising from the absence of greasing axle boxes, etc.

We will now consider the general conditions of working of the two systems. The sliding railway may be placed in the category of a rope railway propelled by water instead of by a rope. In each case the locomotive of the ordinary railway is replaced by motive power supplied at fixed intervals along the line.

The advantage of the water propulsion is that it is applied at each point at the moment and in the amount which is wanted; and although the first installation would have to be adapted to the maximum traffic to be expected, the consumption of water would strictly correspond with the actual weight of traffic; whereas the whole weight of the rope has to be set in motion, and the rope continues to move along the whole length of the section during the passage of each train.

There remains the important point of capital expenditure for establishing the line; that is to say, the cost of the installation of the water main and pumping appliances, the hydrants for propelling the train, the appliances for catching the waste water, and the conduit for conveying it back to the various pumping stations.

Upon these points I have at present no information, and so much depends upon the proportionate sizes of the several parts, that it would not be advisable to submit merely assumed figures; but the comparative lightness of the rolling stock would allow of a considerably reduced expenditure over that of ordinary railways in some of the principal branches of construction.

The experimental railway which M. Barre proposes to erect at Neasden will, it is expected, furnish many necessary details upon these and other points which have not yet been fully explained.

I will now recapitulate the points which M. Barre claims to be the advantages of the system:

1. Smoothness of motion—that is to say, absolute freedom from vibration or jarring—and absence of dust.

2. Absence of noise and smoke.

3. Small risk of running off the line, because no object, however small, can pass under the skates.

4. Power of stopping almost instantaneously, very smoothly, and without any shocks; diminished chances of collision from meeting trains; power of stopping on a gradient as steep as 45 in 100.

5. Ease in ascending inclines, and in traversing curves with a radius as small as two chains.

6. Power of attaining a speed of 100 miles per hour on the level if the pressure in the water main be increased to a little over 300 lb. to the square inch.

7. Remarkable lightness of the carriages and wagons, which would not weigh above one-half those on ordinary railways; absence of heavy locomotives and tenders; and consequent lightness of bridges and other works of construction.

8. Almost entire saving in cost of traction in mountainous countries in which there are large waterfalls, and very large saving in cost of traction even where all the water has to be pumped.

9. Economy in train expenses, resulting from the abolition of greasing, and from the saving of repairs of wheels, axles, grease boxes, brake apparatus.

10. Large saving on the maintenance of the steam engines; first, because there would be less horse power required to do a given work; and, secondly, because the fixed engines which pump the water would be worked under conditions more favorable for economy than is possible with locomotive engines.

M. Barre gives the following as some of the instances in which the sliding railway could be usefully applied:

1. In mountainous countries where there are large waterfalls, which would supply the water, and in which the inclines are greater than ordinary railways can surmount.

2. On cable railways, especially those with steep inclines, where the use of wheels sometimes causes serious accidents, the cable traction might be continued, the water skate alone being employed. If the cable broke, all that would be necessary would be to stop the flow of water into the skate, and the vehicles would come to rest on inclines as great as 45 in 100.

3 For moving heavy weights of large bulk. In this case a mechanical traction by means of rack and pinion work could be resorted to, the sliding arrangement alone being adopted.

The use of springs for equalizing the weight on the several supports would be replaced by hydraulic cylinders, in which the rod which supports the weight on the skates would become the piston. The cylinders would carry the framework and be associated into groups; the cylinders in each group being in communication, but each group being independent of the other groups. Under these arrangements any slight difference in the levels of the rails would be compensated.

For moving large guns placed in cupolas for coast defense, the sliding system would afford peculiar advantages, as well as for the transport across an isthmus of large vessels floating in caissons. For this latter application of the system, it may be mentioned that an iron caisson 600 ft. long and 60 ft. wide, affording 26 ft. draught of water, would weigh about 44,000 tons in complete working order. It would suffice for supporting this to have 432 skates, each one meter wide by two meters long, supplied with a water pressure of about 70 lb. per square inch; and it would require 8,000 horse power to propel this at a rate of a little over two miles per hour on an incline of 1 in 143.

4. In metropolitan railways, where the traffic is continuous, small trains, holding say 100 seats each, could

follow each other at rapid intervals. If these railways are underground, the system would afford the special advantages of absence of smoke, noise, and dust, as well as smoothness of motion, and great speed between stations situated at short distances apart.

For overhead railways, the facility of passing round curves, and on steep gradients, as well as the absence of smoke and noise, would be specially advantageous, while the viaducts might be of very light construction compared with those required to be used by locomotives. The columns supporting the line would form accumulators for the water under pressure, and all the parts could be carefully protected from frost.

5. M. Barre states, in conclusion, that the sliding railway seems to be especially suited to the Channel tunnel, in which the train might, on arriving at one end, be passed on to a truck on skates, and conveyed through the tunnel in a quarter of an hour; and if the line were extended on both sides of the Channel, to London and to Paris, the time of transit between the two cities need not exceed two hours.

It may be assumed that, given a very high pressure to the water of propulsion, very great speed might be obtained on this railway with absolute smoothness of motion and freedom from dust, which would constitute the perfection of traveling, and would undoubtedly be a most luxurious mode of progression. But in the absence of sufficient experimental data upon which the actual quantities of water required for propelling the train could be safely based, it is quite impossible to argue how far such a system might be made applicable to general conditions of traffic. This question will, however, receive an early solution.

In the first place, the company of the *Chemins de Fer Glissants Perfectionnés* proposes to fit up a line of a short length, with complete apparatus, in England, in the course of the present year, and Sir Edward Watkin has placed a site at their disposal at Neasden.

In addition to this, the company have applied, under the date of the 7th of February last, to the municipality of Paris for permission to construct an elevated metropolitan railway in Paris, between the Place Clichy and La Villette. The line is intended to follow exactly the curves and gradients of the central footway in the Boulevards between these two points. It would be carried upon an elegant trellis work, of which the supporting columns would be light, and would in no way impede the traffic. Hydrants would be placed on each side, at distances apart of forty meters, the water supply being under a pressure of about 140 lb. per square inch.

It is proposed to run trains containing 100 passengers each at intervals of one or two minutes, which would admit of 12,000 passengers per hour being carried in the two directions.

There would be three intermediate stations between the Place Clichy and La Villette, one at the Place Pigalle, another at the Boulevard Ornano, and the third at La Chapelle. The distance, somewhat over four miles, between the Place Clichy and La Villette, including the stoppages at the three intermediate stations, is intended to be traversed in seven minutes. The charge for the whole or any part of the distance would be 10 centimes for second class and 20 centimes for first class. The floor of the carriages would be on a level with the platforms, and the carriages would be lighted by electric light, and would be warmed in winter.

In addition to staircases for ascending and descending, each station would be provided with hydraulic lifts, to be worked continuously, for raising passengers from the street level to the railway platform, where a train would always be ready to start.

In conclusion, I may mention that the model of the sliding railway, which was erected and worked at the Paris exhibition, is about to be transferred to the exhibition at Edinburgh, where it will be run continuously, as it was in Paris.

PROPOSED BRIDGE AT NEW ORLEANS.

THE New Orleans Terminal Railway and Bridge Company proposes to erect at a point near the lower limits of the city of New Orleans a high level railway bridge across the Mississippi River, on the plan as shown in the engraving, being the design of Mr. Thos. C. Clarke, C.E.

The company is composed of representative bankers and merchants of New Orleans, who are entirely familiar with the commercial interests of the city, both as regards railway and river necessities, and at the same time are identified with those interests, and bound to care for and foster all, without unduly endangering any.

Recognizing the fact that the wants of the large trans-Mississippi railway business demand a more convenient, speedy, and economical means of crossing our great river at this city than is afforded by the ferry boat system now in use, and that this transfer business is increasing daily; and also keeping in mind the importance of absolute non-interference with the rapidly developing barge and towing system of river commerce, the company determined to apply to Congress for permission to bridge the river at a point *below* this river traffic, and to erect such a bridge as shall in no manner interfere with or obstruct the ocean commerce coming to this port.

This steamboat and barge traffic, bringing to New Orleans, as a point of export, the products of the great West and Northwest, all terminates *above the foot of Canal street* in New Orleans; hence, a bridge so constructed as to allow of the free and unobstructed passage of ocean vessels, located in the long straight reach of the river below Canal street, would not only be conveniently accessible to all railways, but would also be entirely out of the way of the great river traffic.

The great and growing importance of this barge or towing system to the producers of the Northwest is clearly shown by the following extracts from a memorial submitted to Congress on this subject by the practical steamboatmen of the Mississippi and all tributary rivers:

"A towboat frequently handles 31 barges and 22,285 tons (44,570,000 lb.) of freight at a time; and it cannot be handled or managed at will, or so readily as a steamboat. There are occasions when, owing to the wind, to the strong and varying currents, or to bad places in the river, a tow cannot be kept perfectly straight, and is obliged to pass places in a flanking position, sometimes stretched sideways across the river. It is a difficult matter to avoid running into the banks, and a wide channel or passageway must be had for the length rather than the breadth of the tow—the length of one tow being as much as 1,015 feet, the width 262 feet, the average length of the coal tows being 990 feet, width 160 feet.

"Upon this depends, to a large extent, the cost of transportation. The value and importance of the towing system is universally conceded, and the cost of such transportation depends upon the size of the tows that can be safely taken down the river; and their size depends mainly upon the condition of the river and the construction of the bridges through which they will have to pass. If these are not large enough to permit safe and easy passage, then the size of these tows must be reduced, or the boat must take its tow through in sections. It can be readily seen that faulty bridges, low and narrow spanned, seriously interfere with this cheap and easy system of water transportation by tows, increase the freight rates by river, which is followed in turn by a similar advance in railroad rates, and the result is felt at all points from the valley to the coast.

"The government has already made some valuable improvements in the river, which have greatly lessened the dangers and reduced the cost of navigation.

"This has naturally been followed by a reduction in the freight rates by river. Other works now under way will still further improve navigation, and reduce these rates, and they will enable cargoes of even greater bulk to be transported. Coal is now being brought from Pittsburg to New Orleans, a distance of over 2,000 miles, at 75 cents per ton freight, insurance and other costs included. It is transported at this phenomenally low cost—the lowest cost of transportation the world has ever known—simply because it can be brought in such large quantities; one towboat having brought in one tow, and at one time, 39 barges loaded with 31,388 tons or 826,011 bushels of coal.

"The interests of the people demand that the commerce by river shall not be circumscribed, endangered, or obstructed in any way.

"Even if the interests of the carriers, owners, crews, etc., are not to be considered in this important matter, surely those of the people, of the producers and consumers, deserve consideration; the injury and loss to be inflicted upon them cannot be overlooked or ignored; and they will be seriously affected, and greatly injured, whenever any additional burdens or expense are forced on the steamboat.

"The great valley fully recognizes the importance and value of an alternate route to the seaboard, by the tributaries and down the Mississippi. It has found that this route and the competition it affords fixes the rate of through freight, as do the lakes and the Erie canal.

"This competition can be destroyed, this regulator of rates and prices can be abolished, by allowing improperly located and constructed bridges, thereby increasing the difficulties and costs of navigation. A bridge of this character stops navigation far more effectually than ice in the lakes or canal, for ice remains but a brief season, whereas the bridges are a hindrance and an obstruction for all time and at all seasons.

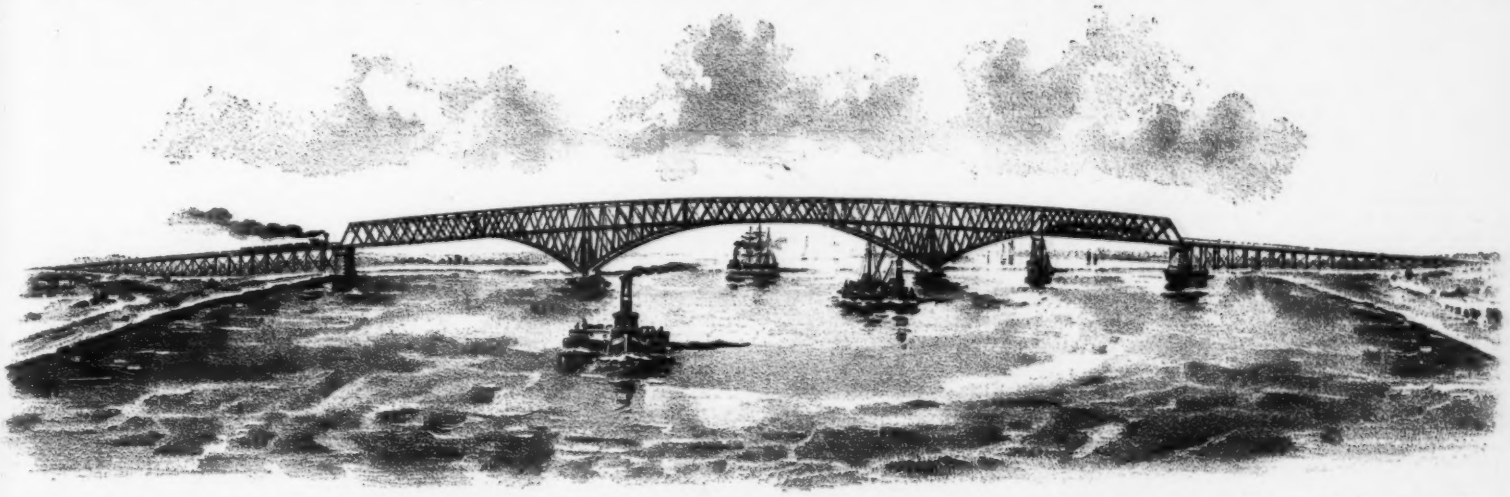
"The number of tows of grain, coal, cotton seed, and other products which arrived in New Orleans in the year ending June 30, 1889, were 180, with an aggregate cargo tonnage of 1,136,750 tons.

"These tows, owing to the bars, tortuous channels, cross and strong currents, points and bends in the river, have to be placed ahead, the steamer, in the rear, serving as a rudder to the fleet. In this shape the tow comes a thousand miles or more, under full way, floating or backing in a straight or flanking position, as the exigences of the river require, controlled at times with difficulty. With a heavy wind against it, it requires as free and open a river as can be given, and a faultily placed or constructed bridge at New Orleans will seriously endanger its safety and greatly interfere with or delay its passage."

From these extracts it will be evident that any bridge having piers in the river above the foot of Canal street, in New Orleans, endangers this immense barge commerce, and tends to destroy the value of the river, not only as a cheapener of freight rates between the producer and the consumer, but as a conservator and regulator of such transportation charges.

For these reasons the New Orleans Terminal Railway and Bridge Company selected as a location for their bridge a point on the river *below this commerce*, and have adopted a plan which will insure entire freedom of passage to all ocean-going vessels.

Concerning the bridge, Mr. Clarke says: "The middle span will be 1,200 feet long and 165 feet above high water at the center, and there will be a clear space between the piers of this middle span of 1,150 feet. For a space of 500 feet this span will be 150 feet, and for 900 feet it will be 120 feet above high water. The shore spans will each be 800 feet long, and the clear headway at the shore piers will be not less than 80 feet above high water. I propose, in the construction of the bridge, to use the Abt system of rack rail, and to adopt a grade of 7 per cent. from the center of the bridge, thus securing comparatively short approaches and a very large saving in cost. The Abt rack rail system is now so thoroughly perfected that the difficulties in surmounting high grades have been largely reduced. An Abt locomotive can draw as many cars as the size of its boilers and cylinders give it power to do; limited, in the case of the European railways, by the strength of the drawbars which connect the cars. In your New Orleans bridge I propose to take over the trains by two locomotives, one in front and one behind, so that in case of breaking of a drawbar the train could not break in two and run away in either direction. By this plan I can draw as many cars as the two locomotives have power to pull. A consolidation engine, weighing, with loaded tender, 75 tons, can draw, in addition to itself, 2,675 tons on a level. As the resistance of gravity is directly as the grade, it could draw on a 7 per cent. grade one-seventh, or 382 tons, if it only had adhesion enough; but as a matter of fact it can only draw 74 tons. But if we give it adhesion by the Abt rack rail system, it can draw 382 tons. We prefer to divide the power into two engines of about 60 tons each, for the reasons previously given. They could draw about 275 tons each, or both together a train of 550 tons. If they depended on the safe load on the drawbars, they could only draw 184 tons each, but by the simple and safe plan of dividing the power and putting one engine before and one behind the train, we can do as above. As a matter of fact, it will cost no more to draw cars over the 7 per cent. grades, worked by the Abt system than by 2 per cent. grades worked by ordinary engines, when the saving of interest is taken into account. As these trains could follow each other safely at ten minutes intervals, we could draw over two tracks in two hours' time the whole number of cars which now cross the ferries daily."



PROPOSED HIGH LEVEL RAILWAY BRIDGE ACROSS THE MISSISSIPPI RIVER AT NEW ORLEANS, LA.—DESIGNED BY THOMAS C. CLARKE, C.E.

EXPERIMENTS WITH LIFEBOAT MODELS.*

By Mr. J. CORBETT.

THIS paper forms part of one submitted to the committee of the Lifeboat Institution in May, 1889. The committee honored me by accepting some of my suggestions, and by requesting their naval architect, Mr. G. L. Watson, to embody any he approved in a design for a large sailing lifeboat, not self-righting.

But my investigations and experiments were chiefly directed to the improvement of the small self-righting rowing lifeboat; and to this end I earnestly request the opinion of members of the Institution of Naval Architects on my suggestions in this paper.

During more than twenty years past I have taken every opportunity of gathering information about lifeboats from those most conversant with their qualities and duties; but since the Southport disaster, three years ago, most of my available leisure time has been occupied in reading lifeboat records, collecting draw-

* Paper read before the Institution of Naval Architects.—*Engineering*.

ings of existing boats, obtaining models carefully built to scale,* testing these models in sea waves and breakers of proportionate size, and also testing them in still water with appliances for recording their qualities. Though such study of the subject cannot possibly compensate for my lack of actual experience of lifeboat work, still I hope it may excuse my presuming to speak here on so very debatable a theme.

I owe thanks to the chief inspector and other officers of the Royal National Lifeboat Institution for supplying me with drawings and much of the information on which this paper is founded. I have also to thank several firms who build lifeboats, and many experienced lifeboat coxswains, for practical information on many points.

My object in these experiments and in the accompanying investigation and comparison of the dimensions and qualities of lifeboats used by the Royal National Lifeboat Institution, is to call attention to the remarkable diversity, and even opposition, in some of these qualities, and possibly to deduce some valuable data which may beneficially influence the design of future lifeboats.

Though crude experiments with lifeboat models were tried by the South Shields Committee in 1785, and by the Northumberland Prize Committee in 1851, I believe no methodical or scientific experiments have ever been made with either lifeboats or their models; and while curves of stability and almost every conceivable test and calculation have been made for war ships, merchant steamers, and racing yachts, I show now, probably, the first curves of stability ever ascertained for lifeboats.†

The types of boats experimented upon include:

1. The Norfolk sailing lifeboat, the oldest type now in common use.
2. The tubular lifeboat, first built in 1853, but considerably modified since then.
3. The large self-righting sailing lifeboat, as built in 1887, a modification of the ordinary lifeboat.

These three types, being all 40 ft. or more in length, are represented at one-sixteenth scale by my drawings and models.

4. The self-righting lifeboat, as built in 1862, adapted for either rowing or sailing; this being the first approved type evolved from the experimental self-righting boats introduced in 1851, and the only type of which drawings and specifications were published by the Insititution.
5. The self-righting lifeboat, as built in 1887, being the modern development of the above lifeboat, and the type of which the greatest number have been built in recent years.
6. The side-decked lifeboat, a novel design for a rowing and sailing lifeboat; presently described in detail.

These last three, 33 ft. and 34 ft. long, are represented at one-twelfth scale, so as to be about the same size as those of one-sixteenth scale.

Before comparing the boats now in use, it will be convenient to briefly describe the chief points of each:

Fig. 1.—The Norfolk sailing lifeboat is broad and shallow, with huge fenders projecting from its sides. The whole space beneath the deck is filled in by detached air cases, except where occupied by loose water ballast. There are no seat thwarts, and when oars are used the men stand to them. The loose water ballast is in open central spaces; water also lodges among the timbers in the space between the air cases and the outer skin of the boat. There are open tubes through the bottom, to discharge any water coming on board. The load displacement of this boat is about 16 6 tons, and its total bulk to the gunwale is about 42 tons.

Fig. 2.—The tubular lifeboat, as built in 1877, though like the Norfolk lifeboat in its broad, shallow, raft-like form, is utterly unlike it in other respects. Its stability depends entirely on the two tubes forming its main structure, and it carries absolutely no ballast. It is thus, in proportion to its size, the lightest type of lifeboat in use. As originally designed by Mr. Richardson, it had a deck of open battens, and open spaces between the tubes and the top sides, so that no water could remain on deck, and a sea could pass across it or through it without much liability to capsizing. But this very open structure rendered the boat almost intolerably uncomfortable for the crew. Each boat recently built has a nearly close floor and close sides, protecting the crew, but giving an excessive capacity for retaining water breaking on board, and rendering the boat much more subject to capsizing by the blow of a sea. They have also a very singular and dubious arrangement of hinged floor planks on each side, which lift and admit water in bulk from below; and as this water has only small openings and relief valves to escape by, it follows, naturally, that the boat is sometimes water-logged for considerable periods. These boats are found remarkably well adapted for towing. I think this good quality is given by the numerous iron bolts and frames which connect their tubes, dragging heavily through the water, and acting as a powerful drogue, making the boat hang steadily on the towing hawser. On the other hand, this constant drag greatly hinders the boat's sailing or rowing, and there is a constant liability to catch wreckage or seaweed on the exposed frames beneath the boat. The load displacement of this New Brighton boat is 8 tons, and its total bulk 35·5 tons. The old tubular boat at Rhyl has a load displacement of only about 4½ tons. The tubular lifeboat supplied to New Brighton in 1888 is in most points decidedly superior to these older boats, but as yet has not been used on service.

Fig. 3.—The large sailing self-righting lifeboat is an extreme example of the self-righting type. Its high end air cases add greatly to the end area of the boat, seriously hindering progress to windward. At the same time they give an excessive height of side exposed to the blow of a sea. The ballast consists almost entirely of the iron keel and the iron drop keel and casing. There are some closed water ballast tanks intended for use if the drop keel is lost. It is fitted with thwarts and swivel rowlocks for twelve oars, and also the usual rudder and steering oars. It is self-righting, either empty or with crew and gear on board. The boat is remarkably light loaded, its loading displacement being about 9·8 tons, and its total bulk 41 tons.

Fig. 4.—The self-righting lifeboat of 1862, for rowing or sailing, is so shallow in draught and comparatively broad in beam as to be only just self-righting without crew or gear. It has thwarts and swivel rowlocks, etc., for ten oars. The fine lines and fair breadth of beam adapt it well for sailing; but the draught is so limited as to prevent holding well to windward, especially in broken water. The ballast consists of an iron keel, and also some cork or light wood under the floor, near the center of the boat. The load displacement is about 5·3 tons, and the total bulk about 17·3 tons.

Fig. 5.—The self-righting lifeboat of 1887, for rowing or sailing, is a modification of the last one, especially designed to give self-righting power, even under difficult circumstances. The beam is reduced, and the lines much fuller at bow and stern. The draught is increased 4 in., thereby giving increased power to the heavy iron keel. Many details of the upper structure of the boat are lightened to aid in lowering the center of gravity. The end air cases are considerably enlarged, partly by lengthening the boat a foot, and by reducing the space for the crew by 8 in. in length. Water ballast tanks are provided under the floor, holding 7 cwt. All these alterations from the old type tend to give increased self-righting power; and some of them tend to increase the power of sailing to windward. The narrow beam reduces the sail-carrying power. On the other hand, the side air cases are slightly enlarged, tending to give more stability when immersed, but to reduce the self-righting power when completely capsized. The boat is self-righting, either empty or with crew and gear. The load displacement is, like the older boat, about 5·3 tons, and the total bulk 17·5 tons. Some of these boats have been fitted with drop keels, giving them good weatherly qualities, so that they decidedly excel the other boats when close hauled, though not when running free. These boats pitch and roll less than the older type, partly owing to their shape, but probably chiefly to their weights being less concentrated, by omitting the cork ballast, adding copper air cases below the deck, and enlarging the end air cases.

Form of Side and Gunwale.—This is an important item, and the height of side perhaps even more important, for though the capsizing power of a wave attacks the lifeboat both below and above its water line, it is usually the blow of a sea on the upper part of the side that does most injury. It is therefore desirable to keep the sides as low as practicable.

There is an urgent reason in favor of low sides, that they are less distant in height above the center of gravity of the boat; for when a boat is violently struck on the broadside, and is thrown twenty yards or more sideways by the blow, the chief resistance which the boat offers to the rushing sea is simply its weight, its inertia; so it follows that when such an overpowering blow is received by a low-sided boat with but little keel, the boat may not be capsized, but only driven sideways; while the same sea striking the high sides or ends of a self-righting boat, would find a high area to receive the blow, and a low center of gravity to resist it, and consequently the boat would roll over instead of merely driving along sideways.

But the blow of the sea broadside on, when it cannot be avoided or reduced, may readily be evaded or rendered comparatively harmless by means of sloping or "tumble-home" sides to the boat. The blow of a sea is received by the boat square to the surface on which it strikes, and in proportion to the area of exposed surface; just as wind pressure is received square to the surface of a sail, and in proportion to the sail area. Therefore a wave blow on the "tumble-home" part of the boat's side actually tends to heel the boat to windward, and thus to reduce the capsizing power of the blow. An incidental gain by "tumble-home" sides is the reduced space for water coming aboard, and another gain for rowing lifeboats is that the narrower gunwales over a broad hull rise and fall less when rolling, and therefore rolling causes less inconvenience to the rowers.

Relative Form of Bow and Stern.—In most lifeboats they are almost identical in form, and it seems to have been the practice many years ago to sometimes row the boat stern first rather than risk turning about in rough water. But a sailing lifeboat cannot practically be sailed stern first, and a rowing lifeboat is so seldom backed that the relative duties of the two ends may be properly considered separately—discussing first the requirements for sailing or rowing to windward against a heavy sea, this being the most difficult duty of a lifeboat.

The bow must needs be comparatively fine in form to reduce the shock of each wave or of a running sea. It must have a considerable surplus of buoyancy, so as to rise to each wave, but must not have such an excess of buoyancy or of horizontal area as would raise it high above the wave, thereby losing way and giving the wave a chance of turning the boat end over end. The bow should be decked over for some length, so as to permit of running into a wave and rising through it without taking much water on board.

The stern has altogether different duties when the boat is going to windward. Any reasonably fair form will enable the water to close in the boat's wake without undue drag. Full quarters would so extend the water plane area as to offer a valuable resistance to depression when the bow is rising to a wave, thereby maintaining headway, and preventing the boat rising on end; and this can be effected with comparatively fine lower lines below the full quarters. Stability for sailing, or to resist capsizing, would be greatly increased by thus continuing the breadth further aft; and in every way it appears that for going to windward a fine and moderately high bow and a broad and comparatively low stern and fairly deep keel and rudder would best give the qualities required.

For running free the very same qualities are required, with the additional consideration that the bow must not have too lofty a side, since the blow of a sea on one side of the bow has been one of the causes of capsizing. If the gunwale amidships can be kept low, or made of a tumble-home form, it will further help to reduce the blow of a sea.

In running before the sea, and especially in landing

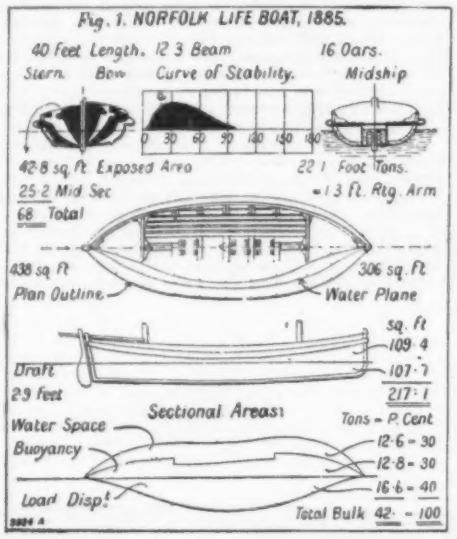


Fig. 1. NORFOLK LIFE BOAT, 1885.
40 Feet Length. 12 3 Beam 16 Oars.
Stern. Bow. Curve of Stability. Midship
42·8 sq. ft. Exposed Area 22 1 Foot Tons.
25·2 Mid Sec = 1·3 ft. Rtg. Arm
68 Total
438 sq. ft. 306 sq. ft.
Plan Outline. Water Plane
sq. ft
109·4
107·7
217·1
Draft 2·9 feet
Sectional Areas.
Tons = P. Cent
Water Space 12·6 = 30
Buoyancy 12·8 = 30
Load Displ.t 16·6 = 40
Total Bulk 42· = 100

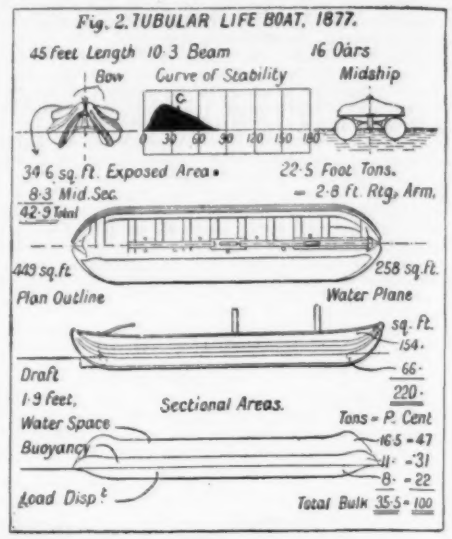


Fig. 2. TUBULAR LIFE BOAT, 1877.
45 Feet Length 10·3 Beam 16 Oars
Bow Curve of Stability Midship
34·6 sq. ft. Exposed Area. 22·5 Foot Tons.
8·3 Mid. Sec. = 2·8 ft. Rtg. Arm.
42·9 Total
449 sq. ft. 258 sq. ft.
Plan Outline Water Plane
sq. ft.
154·
66·
220·
Draft 1·9 feet.
Sectional Areas.
Tons = P. Cent
Water Space 16·5 = 47
Buoyancy 11· = 31
8· = 22
Load Displ.t
Total Bulk 35·5 = 100

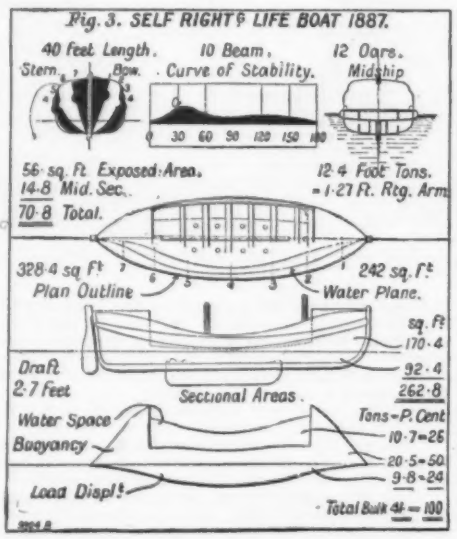


Fig. 3. SELF RIGHTG LIFE BOAT 1887.
40 Feet Length. 10 Beam. 12 Oars.
Stern. Bow. Curve of Stability. Midship
56· sq. ft. Exposed Area. 12·4 Foot Tons.
14·8 Mid. Sec. = 1·27 ft. Rtg. Arm.
70·8 Total.
328·4 sq. ft. 242 sq. ft.
Plan Outline. Water Plane.
sq. ft
170·4
92·4
262·8
Draft 2·7 Feet
Sectional Areas.
Tons = P. Cent
Water Space 10·7 = 26
Buoyancy 20·5 = 50
9·8 = 24
Load Displ.t
Total Bulk 41 = 100

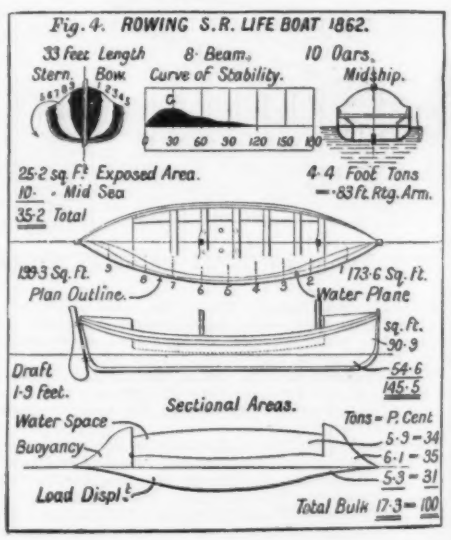


Fig. 4. ROWING S.R. LIFE BOAT 1862.
33 Feet Length 8· Beam. 10 Oars.
Stern. Bow. Curve of Stability. Midship.
25·2 sq. ft. Exposed Area. 4·4 Foot Tons
10· Mid Sea = ·83 ft. Rtg. Arm.
35·2 Total
139·3 Sq. ft. 173·6 Sq. ft.
Plan Outline. Water Plane
sq. ft.
90·9
54·6
145·5
Draft 1·9 feet.
Sectional Areas.
Tons = P. Cent
Water Space 5·3 = 34
Buoyancy 6·1 = 35
5·3 = 31
Load Displ.t
Total Bulk 17·3 = 100

* My models were made by Mr. C. Bathurst, Tewkesbury; very accurately and well built to my drawings.

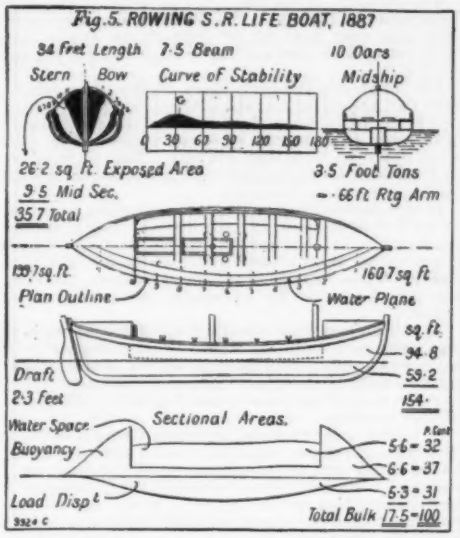
† Professor Osborne Reynolds read a paper at the Manchester Literary and Philosophical Society, on December 14, 1886, "On Methods of Investigating the Qualities of Lifeboats," with special reference to the non-righting of the Southport lifeboat the week before, in which he advocated experiments with models.

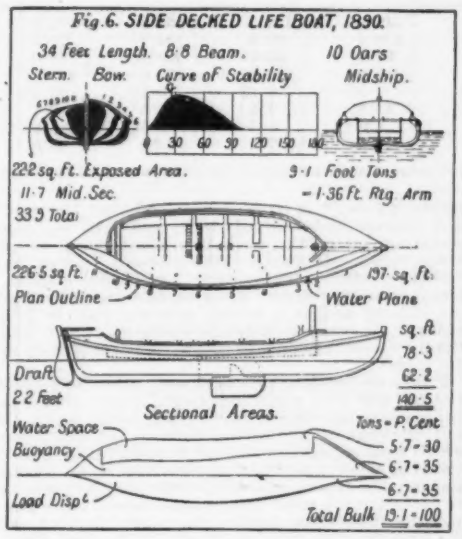
through heavy breakers, somewhat opposite conditions are met with, but none which would render it desirable to take such a lifeboat in stern foremost.

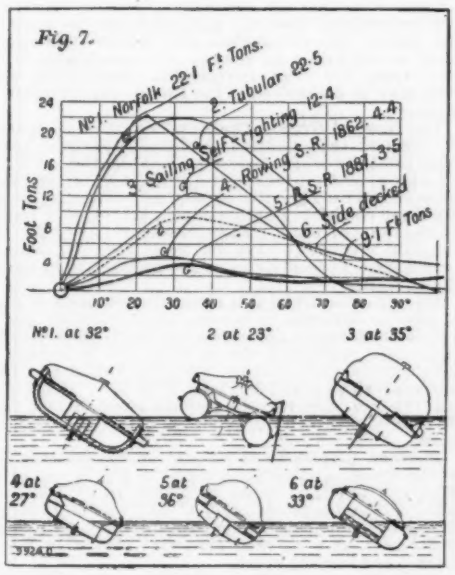
The great desiderata here are that the bow end shall have ample buoyancy to prevent its burying when a wave overruns the stern; and that the stern shall have a deep grip of the water, and comparatively low sides, to prevent its being turned aside by the blow of a sea on one quarter, the most frequent cause of broaching to and capsizing. Being overtaken and pooped by a following sea, the direct peril of an open boat running through breakers, is comparatively harmless to a lifeboat whose buoyancy depends on air cases; and therefore a low stern with somewhat deep keel and a high bow, with considerable surplus of buoyancy, will best meet the requirements.

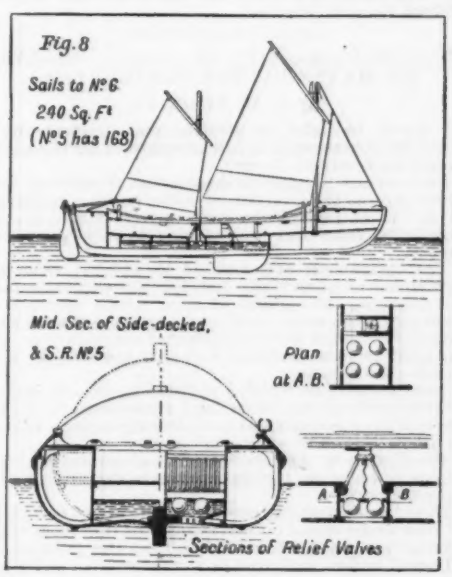
Thus whether rowing or sailing to windward, running free, or running before the sea, a fine bow with considerable surplus of buoyancy and a broad stern with but a moderate surplus of buoyancy seem safest and best for lifeboat work.

Curves of Sectional Areas.—These diagrams, and especially those of each boat's bulk above water, indicate well the comparative merits of the several forms for forcing their way through breakers and high wind, which I have also endeavored to ascertain by the towing experiments presently described. The curves indicate one of the many detriments involved in the









self-righting system; all the self-righting boats having curves, or, I should say, angular lines of sectional areas above water, seriously detrimental to boats specially intended for making good headway through rough water. The proportions of immersed and emersed buoyancy, and the comparative bulks in each end, and in the middle where lateral stability is mainly obtained, can well be studied on these diagrams.

Proportions of Weight to End Area.—The total end area of a boat in comparison with its weight is almost a criterion of its power of facing rough water, since impetus is essential to holding the boat's way when meeting a sea. In the huge-ended sailing self-righting boat, there is only 310 lb. of total weight per square foot of end area; and in the 1887 rowing boats 333 lb. per foot of end area; while the Norfolk boat has 546 lb. per foot of end area. These boats being all of shapely form are fairly comparable, but the tubular has such blunt shapeless ends that it would need an excesive weight to hold way against a sea. It has 418 lb. per foot of end area, and is, in fact, not so good in this respect as the self-righting boats. It is beyond controversy that the Norfolk boat has an immense advantage over all these other types of lifeboat in this power of holding its way through a sea; and this mainly in consequence of its heavy weight per square foot of end area. The side-decked model represents 443 lb. per foot of end area, or one-third more than the self-righting boats of similar size.

Towing Resistance against Head Wind and Sea.—This quality was ascertained by towing the models to windward against breezes of fifteen to twenty-five miles an hour in an exposed reservoir. My purpose is to compare each boat's fitness for rowing or sailing to windward against high wind and sea.*

My experiments tend to prove that, when going to windward, just as much resistance is caused by the above-water surfaces, which met the flying spray and broken water, as that caused by the immersed parts, which are in less disturbed water. And also that fineness of form, and absence of flat or blunt ends, either above or below water, tends to easy progress to windward. Thus the towing resistances in the line, R, of the table are almost exactly in the ratios of the total end outline areas in line, J, after allowing for the addition of the crews; except for the blunt tubular boat. And of the three large lifeboats, the tubular shows the greatest towing resistance, though of the smallest displacement, owing to its large, blunt, exposed ends. The self-righting boat has only slightly less resistance than the tubular, though of very light displacement and fair form; its high end air cases offering so much resisting surface. The Norfolk boat, with heavy displacement, shows rather less towing resistance than the light self-righting boat, owing to its having so little exposed surface above water. The three small lifeboats show the same indications, the side-decked lifeboat carrying 1·4 ton more load than the other two, with no increase in towing resistance, owing to its reduced surface and less angular form above water, proving that a boat with more than double the stability of the ordinary lifeboat need not be any harder to row.

Curves of Stability.—The curves of stability of these varied lifeboats at load draught, on diagram, Fig. 7, form the most suggestive data for comparisons, and possibly for future improvements, of any I am able to produce.†

Each diagram is marked with the "length of righting arm" in feet, and with the greatest stability in foot tons. These figures give criteria of each boat's sailing power, but I have endeavored to further indicate the sailing power by figures in line, U, of the table, founded on the towing experiments; these these figures being the quotients of the foot tons of stability divided by the towing resistances. Of course, the actual beating power of a boat depends not only on its sail-carrying power in proportion to its towing resistance, but also on its lateral area to resist leeway. Any of these boats could be equally well provided in this respect by means of keels or drop keels.

The remarkably full curve of stability of the tubular boat shows the greatest righting moment at 30 deg., and of the large amount of 22·5 foot tons.

The Norfolk boat, celebrated above all for its sailing qualities, has its greatest stability at 32 deg., and of the high amount of 22·1 foot tons.*

The large sailing self-righting boat has an alarming deficiency of stability, showing a maximum of only 12·4 foot tons at 35 deg., or only about half the stability of either the tubular or the Norfolk boat.

The self-righting rowing lifeboat of 1862 has the inadequate stability of 4·4 foot tons at 27 deg. The modified boat of 1887 has only 3·5 foot tons at 36 deg.

The side-decked lifeboat has 9·1 foot tons at 33 deg.; proportionately the greatest stability of any of the models.

It is not only at moderate angles that the self-righting boats, as compared with the non-righting boats, show lack of stability, the average stability of each boat up to 90 deg. being as follows:

No.		Foot Tons up to 90 deg.
1.	Norfolk sailing lifeboat, average	13·7
2.	Tubular	10·4
3.	Sailing self-righting	6·8
4.	Rowing " 1862	2·5
5.	" " 1887	2·0
6.	Proposed side-decked lifeboat	5·4

These figures certainly show so serious a lack of stability in all the self-righting boats as to fairly warrant their nickname of "roly-poly boats;" in fact, more than 60 per cent. of the available stability is sacrificed to obtain the self-righting power.

Self-Righting vs. Non-Righting.—My experiments and comparisons lead to criticism of many varied elements in these boats, but it is impossible to overlook the fact that the most important debatable element is that of self-righting when completely overturned. So far as this valuable quality can be provided without too much detriment to other more important qualities, it is of very great value, since capsizing is the most serious risk to which a lifeboat is exposed. But a boat of shallow draught can only be made self-righting by limiting its beam, and hence its stability at all working angles of heeling; in order that the "shoulder stability" shall not, when capsized, annul the righting tendency of the center of gravity.

The officers of the Lifeboat Institution have recently effected a great increase in this quality of their boats, by the enlargement of the end air cases, greater rise of floor amidship, the addition of 2 in. depth of keel, and the reduced beam in the lifeboat of 1887, as compared with that of 1862.

This increased righting power is well shown by comparison of the curves of stability of these two boats, the modern boat self-righting, whether empty or loaded, while the old boat is only just self-righting when empty, and loses stability at 120° when loaded. But this increased righting power when capsized is obtained by sacrificing one-fifth of the stability when not capsized; and it is quite evident that the common statement that the features which give the self-righting power also increase the stability of a lifeboat, is utterly erroneous and misleading.

It appears certain that the frequent disastrous capsizes of the small rowing lifeboats might be almost always prevented by giving them considerably more stability; for of the larger self-righting boats, ranging from 37 ft. by 9 ft. up to 46 ft. by 11 ft., only one has capsized on service, the Thorpness boat, 37 ft. by 9 ft. 4 in., rowing twelve oars. I estimate the displacement of this boat at about 8 tons, and its stability at about 8 foot tons.

It is possible by heavy ballasting, and by a modification of the usual proportions of the boat, without any increase of draught, or of weight when on shore, to provide a lifeboat with fully twofold greater stability, and with threefold more resistance to capsizing by a sea, than a self-righting boat has; and I respectfully submit that this greater stability, with better rowing and sailing qualities, would amply compensate for the absence of the self-righting quality.

The Side-Decked Lifeboat.—I venture to bring under your notice, by a model and drawings, an attempt to embody in one design many of the good features of the five existing types of boat already described. Further consideration and experiment would certainly modify this design in many points, but even in its present crude form it suffices to show the possibility of a considerable departure from any accepted form of lifeboat, with apparently some decided improvements, and with no detrimental features more noticeable than those existing in types of boat which are proved to be tolerably good.

This boat is 34 feet length over all, and 8 ft. 9 in. beam, rowing ten oars; its most peculiar feature is side decks, or tumble-home sides, whichever they may be called, at about 45° angle from the gunwale to the low fenders.

These, together with the deep sides of the hull, give a lateral stability at load draught 160 per cent. greater than the approved rowing self-righting boat. The sloping sides give little hold to a sea striking the broadside.

The rowlocks, placed on a gunwale of 7 ft. 6 in. beam, like an ordinary lifeboat, will heel much less than rowlocks at the full breadth of the boat.

The low but unusually long bow air case is intended to give an easy lift in entering a wave; while the full stern steadies the boat and prevents the bow from hammering unduly over short waves, or rising on end against a high breaker.

The narrowed bow end of the working space tends to keep out the water when heeling over. The slight coamings at bow and stern, and on the gunwales, are shaped to give a good hand grip. The end outline area is rather less than that of the self-righting boat, though the total bulk is 1·6 tons more. The displacement is 1·4 tons more than that of the self-righting boat, and this would be utilized for water ballast, so as to increase the stability and momentum of the boat without adding to its weight when on shore. By thus adding 1·4 tons of ballast to the bulk, its great water

* The models were towed in pairs, attached to each end of a line passed through a pulley on the end of a fishing rod. The boats' sterns were attached to the ends of another line on which a score of 1 in. wooden balls were spaced. These formed a self-balancing counterpoise by which the increased resistance of the rearmost boat could be observed accurately. The actual pull was measured by a 1 oz. weight at the end of the tow line of the standard boat working through the pulley on end of rod. Check experiments were also made in various ways.

† The curves were ascertained in a tank of salt water. The model was fixed in a light wooden ring, marked with degrees from the water line on each side. Two cords pass round a groove in the ring; one of them was attached to the side of the tank, level with the submerged side of the ring; the other was carried from the top of the ring horizontally, over a pulley at the opposite side, and down to the scale on which weights were used. The crew and gear were represented by wood and lead, accurately placed. The lee spaces were full of water; so only the effective buoyancy was utilized.

* Mr. G. L. Watson's Southport sailing lifeboat, 42 ft. in length, 13 ft. beam, and about 19 tons load displacement, with low-water ballast tanks, enlarged air cases, and other improvements on the old Norfolk type, has the immense stability of 45 foot tons.

DIMENSIONS AND PARTICULARS OF LIFEBOATS.

Description of lifeboat.	No. 1. Norfolk sailing	No. 2. Tubular.	No. 3. Self-righting sailing.	No. 4. Self-righting rowing and sailing, 1882.	No. 5. Self-righting rowing and sailing, 1887.	No. 6. Proposed side-decked rowing and sailing.
A. Length in feet and decimals.....	40·0	45·0	40·0	33·0	34·0	34·0
B. Beam " "	12·3	10·3	10·0	8 0	7·5	8·8
C. Draught " "	2·9	1·9	2·7	1·9	2·3	2·2
	p. cent.	p. cent.	p. cent.	p. cent.	p. cent.	p. cent.
D. Load displacement..... .. tons.	16·6=40	8·0=22	9·8=24	5·3=30	5·3=30	6·7=35
E. Effective buoyancy above load water line .....tons.	12·8 30	11·0 31	20·5 50	6·1 36	6·6 38	6·7 35
F. Water space. . ...tons.	12·6 30	16·5 47	10·7 26	5·9 34	5·6 32	5·7 30
G. Total bulk in tons.....	42·0 100	35·5 100	41·0 100	17·3 100	17·5 100	19·1 100
H. Midship section .....sq. ft.	25·2	8·3	14·8	10·0	9·5	11·7
I. End outline above load water line.	42·8	34·6	56·0	25·2	26·2	23·2
J. Total end outline area..	68·0	42·9	70·8	35·2	35·7	33·9
K. Lateral immersed area.	107·7	66·3	92·4	54·6	59·2	62·2
L. Lateral area above water line	109·4	154·0	170·4	90·9	94·8	78·3
M. Total lateral area.....	217·1	220·3	262·8	145·5	154·0	140·5
N. Water plane area	306·0	258·0	242·0	173·6	160·7	197·0
O. Plan outline area.....	438·4	449·0	328·4	199·3	199·7	226·5
P. Weight per sq. ft. ditto in lbs.....	85·0	40·0	67·0	60·0	60·0	66·0
Q. Ditto, total end area in pounds...	546·0	418·0	310·0	337·0	333·0	443·0
R. Towing resistance. .tons, decimals	0·21	0·24	0·22	0·12	0·11	0·11
S. Greatest stability..... foot tons	23·1	22·5	12·4	4·4	3·5	9·1
T. Average stability up to 90 deg....	13·7	10·4	6·8	2·5	2·0	5·4
U. Comparative beating power S+R	105·0	94·0	56·0	37·0	32·0	88·0

plane and plan outline areas are more heavily weighted per square foot than the rowing self-righting boat.

The lateral outline area is one-tenth less than the self-righting boat, and having much less vertical side, the boat would be able, by this and its stability together, to resist much more of a wave blow than would capsize the self-righting boat.

The weight per square foot of end area, being one-third more than that of the self-righting boat, would give great impetus for resisting a breaker or sea. Its towing resistance is the same as the self-righting boat, and as its sail-carrying power is 160 per cent. greater, its comparative power of sailing to windward is 160 per cent. greater than the self-righting boat. The horizontal square tube or casing within the bow air case, and the opening in the second thwart, provide for easy stowing the masts below the thwarts, and so leaving working room for longer oars.

The large recess in the boat's floor and the ball valves and canvas curtain insure a rapid discharge of any water coming on board. A drop keel of short length would be fitted, but even without this valuable appliance the boat would be well able to beat to windward, from having a deeper keel and lower end air cases than usual.

By omitting two of the usual three battens over the side air cases, these cases are raised two inches without raising the seat height; and the thwarts are also raised to the rowers' seat height, omitting the usual raised seats. The side air cases above deck are of 104 cubic feet, or just double the bulk of those in the ordinary lifeboats, including in this cube the cork filling up to the side decks and gunwales.

Though this model was made too late for comparison with the others in my experiments in sea waves and in sailing on the sea, I have sailed it on sufficiently rough water in a reservoir, in company with the other models, and find that it is remarkably free both from pitching and rolling; that it does not take much water aboard, and discharges such water readily, and that it sails faster and closer to the wind than the other models, all being tried without drop keels. The above table of dimensions and qualities of the five ordinary types of lifeboats, and of this design, will aid comparison.

Scheme for Experiments with Lifeboat Canoes.—More practical experiments than are possible with these tiny models are most urgently needed to solve many of the difficult problems of lifeboat construction. Experiments with full-sized lifeboats have been very reasonably objected to on several grounds: First, their great expense; second, the serious risk to the crews, since such experiments, to be of real service, must be in rough weather; third, the difficulty of meeting with rough weather when so desired.

On the other hand, any experiments with small models without crews fail utterly to truly represent real lifeboat work, since no towing and guiding by the experimenter can really represent the good seamanship of the coxswain and crew of a real lifeboat, on which, as much as on the boat's qualities, the safety of all must depend.

I suggest a medium course that offers really excellent facilities for every form of experiment required. Use lifeboat models of the size of ordinary canoes; let each be managed by a skilled canoeist (and many experienced lifeboatmen are now also canoeists); let wind and sea be chosen of forces in proportion to the smallness of the models; we have then the following advantages: (1) The smallest and therefore least expensive models that can be manned at all; (2) the slightest risk to the smallest crews, since only moderate waves would be encountered; (3) the frequent opportunities for experiments, as suitable waves and winds are often available.

The true proportions for such canoe models may be computed on the basis of one man in the model representing a crew of, for instance, thirteen men in an ordinary lifeboat; his power in paddling being about one-twentieth of the power of ten men rowing. The quicker strokes and more rapid maneuvering of the canoeist would be about in proportion to the shorter dimensions and quicker action of his boat. Even sailing and towing experiments could be carried out thoroughly satisfactorily.

By this plan an ordinary self-righting lifeboat, 34 ft. long and 7 ft. 6 in. wide, would be represented by a model 14 ft. 5⅓ in. long, 3 ft. 2⅛ in. wide, weighing, empty, 4·9 cwt.* I have ascertained that the cost of such a model, substantially built and fully equipped, would not exceed 35*l.*; so half a dozen could be provided, representing each of the lifeboats I show here, for about 200*l.*; and another 100*l.* would suffice to remunerate the crews. Thus, at half the cost of a single lifeboat, and at a merely nominal risk to life, a series of experiments could be conducted which might result in improvements in future lifeboats of incalculable value.

I have undertaken this work only after long consideration, and with much diffidence, owing to my lack of practical experience; but having spent much time and thought on it, having carried out experiments which seem capable of leading to useful results in the hands of experts, and having seen that more practical and reliable experiments may easily and inexpensively be carried out, I most respectfully submit this paper, in hopes that it may tend in some slight degree to solve the long standing problem of what is the best form of lifeboat for coast service.

ON A NEW METHOD OF COLOR ANALYSIS BY MEANS OF THE TINTOMETER.†

By J. W. LOVIBOND.

I HAVE to-night to describe and illustrate by a series of experiments a new instrument for the analysis and registration of color.

I do not now propose to discuss the theoretical laws which govern the question of color, having endeavored as far as possible to keep myself free in my experiments from any undue bias to any particular theory.

The instrument and method to which I refer is a new means of impartially judging the various colors; for recording the factors of color which combine to form any given color; and a system for registering the same, even in the most complicated combinations and the most delicate shades as well as in the deepest tints which exist in nature.

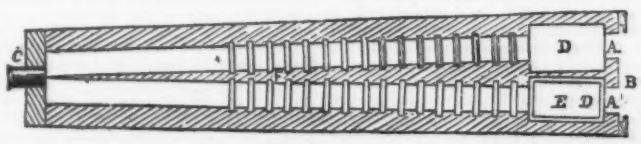
The illustrations which I propose to submit will represent work already done, and those cases where the application is commercial have already become routine in the industries to which they apply.

Description of Apparatus.—The apparatus which is before you now on the table may be divided into two essential parts.

First, an optical instrument which gives two fields of view under equal optical conditions free from errors arising from unequal side lights, from the influence of adjacent bodies, and from any difference of color perception which may exist between the right and the left eye of the observer. The grave extent of error arising from the last cause will be seen on reference to the first set of columns in Table No. 3 on "Neutral Gray," where, out of nine observers, only No. 1 has the color perception practically equal for both eyes; No. 2 equal for red and blue, but varies in yellow as 10·0 to 7·5; No. 3 varies in red as 10·0 to 9·0; in yellow, 10·0 to 7·5; in blue, 10·0 to 14·0; while No. 6 pronounced six observations as tinged with green; these are equally divided between the yellow and blue columns.

The second part is the standard scale, of which I shall speak presently.

The instrument consists of two tubes, A A, side by side, divided by a central partition, B, terminating at the center of the eye-piece, C, in a knife-edge, which, being inside the range of vision, is not noticed, so that light entering the openings, D D, at the opposite end, passes in equal quantities up each tube to the eye of the observer, giving a clear view of any opaque bodies which may be placed outside, or of transparent bodies inside the tubes.



The sides and central partition are grooved in order to hide the edges of the measuring glasses and of the gauged vessels for containing fluids. Stops are placed at convenient distances to cut off light reflected from the sides, and the size and shape of the apertures, D, can be altered by means of diaphragms to suit small or irregular shaped samples.

The Standard Scale.—The second essential part is the standard scale, which consists of sets of colored glass slips, all the glasses of each set being of the same color, but each glass differing in depth of color, the difference being in degrees of equal value throughout the scale.

In all comparisons of a single color, the starting point has been taken as a pure white. The standard white used as a background for the glasses is pure lime sulphate for small surfaces, and for large surfaces, as for the reflectors, the smooth side of Messrs. Chance's opal glass, but whichever is used should be quoted.

I may here say that a comparision of pressed lime sulphate against snow shows no free color in the lime sulphate, which is only 0·25 of a degree of neutral gray less white than the snow itself.

Color Scale.—The relative positions of two-tenths, one degree, ten degrees, and twenty degrees are marked on the color scale of primaries before you.

The equality of the scale can be tested in the lantern by placing a single glass of 20 degrees value on each side and then making 20 degrees by any combinations from other parts of the scale, as 12+7+1 equals 3+8+9.

The Unit.—In the early days of the instrument, before the extent of its application for analytical purposes was fully realized, the necessity of dividing the color scale into degrees of equal value before reliable work could be done was evident. The starting point and value of these degrees were questions of the greatest importance and anxiety.

It was decided to fix upon as a starting point a definite degree of color, the addition of which should be perceptible in the deeper shades, and dividing this degree into tenths and hundredths for the lighter shades, where the perception is keener, thus building up the scale by successive additions of equal value.

It will be seen that the starting point for each color was arbitrary, that the value of the degree in each scale was equal throughout its entire length; but the impure color in the glass then available made the fixing of a unit of common value for each primary color almost hopeless.

A better quality glass, and more recent work, has, however, developed a possible basis for equalizing the value of the unit for the three primary colors, red, yellow, and blue, and which are alone found necessary for most analytical work, and even holds out a hope of constructing a color nomenclature with some degree of scientific accuracy.

I am aware that the colors in my primary standards, red, yellow, and blue, are not pure, but as they are the purest yet obtainable, and as by their means most of the colors in nature are measurable, I will ask that, for the purpose of illustration only, they may be considered as the three primary colors in glass.

The Neutral Gray.—The new departure is founded on the fact that neutral gray under certain known conditions is always made by a combination of 1 red, 1·2 yellow, and 2·4 blue in the original scales, and these proportions hold good at all depths. Then, by assuming these combining values of red, yellow, and blue to be the units of their respective colors, a simple relationship of equality between these three primaries is established, at least so far as the production of neutral gray is concerned.

Having established this common equivalent as a unit of color in reference to neutral gray, by removing the yellow equivalent a normal purple is left, made up of one equivalent of red and one of blue. By removing the blue equivalent a normal orange is left, made up of one equivalent of red and one of yellow. By removing the red equivalent a normal green is left, made up of one equivalent of yellow and one equivalent of blue.

Further, by placing 10 normal orange on each side of the screen, and adding a single degree of red to one side, and a single degree of yellow to the other, we have a 10 normal orange + 1° red, and a 10 normal orange + 1° yellow. Test this further with higher differences, as 5 on each side, and also with normal purple and normal green.

If binary color is taken to be the sum of any two colors composing it, then any departure from the normal toward either primary can be accurately measured and described.

When a color is composed of the three primaries, the units of neutral gray may be deducted as such, and the balance looked upon as free color. Let us see how this works out by matching a somber color, such as brown paper, on the screen, by, say 5 red, 6·3 yellow, and 4·4 blue. The equation may be written thus:

	R.	Y.	B.	N. G.	R.	Y.
Brown paper	5	+ 6·3	+ 4·4	= 4·4	+ 0·6	+ 1·9

The latter part of the equation, 4·4° neutral gray, 0·6° of free red, and 1·9° free yellow, is an accurate description, and conveys an intelligible idea and record of the color itself in this particular brown paper. Test this further by separating the free color from the neutral gray. The method is available for the measurement of all sad-colored bodies.

It also follows that, by the constant addition of neutral gray tints, a scale of equal degrees ranging from white to black may be established, and available for measuring the penetrating power of light.

* These figures, and others used in this paper, are computed on the following proportions to the scales of length: Speeds as the square roots of lengths, areas as the squares, cubes or weights as the cubes.

† A paper recently read before the Society of Chemical Industry, London.

Some precautions are necessary in selecting the proportion of primary colors for the composition of a true neutral gray; for instance, a person whose sight is abnormally strong or weak, even for a single primary, would never agree with an average selection, and this difficulty is increased when the abnormal condition applies to one eye only, as then each eye gives a distinctly different reading. The color of the light must also be considered, as that from a blue sky, a dull sky, or a white cloud gives different results. The angle at which the daylight is taken has also an influence, the light gaining in red as the instrument or reflector declines from the perpendicular to the horizontal.

The proportions of primary colors for the neutral gray standard I have been dealing with are the result of observations taken in the open air, under a dull gray sky, with light as nearly perpendicular as possible, reflected from Messrs. Chance's opal glass, and is the average of 324 observations made by nine persons of my own staff, none of whom are color blind in the ordinary sense of the word, but all have more or less abnormal perceptions for one or more primaries in one of their eyes. I have not, however, removed any of the observations from the table of averages on this account.

A reference to the Table No. 3 will show that of the 324 observations, 130 were pronounced neutral gray, 91 slightly tinged with yellow, 80 with blue, and 23 with red. In no case had the observer a knowledge of what he was judging, and the judgments were frequently checked up and down for truth. But it is quite possible that more extended averages may alter the proportions given.

The difficulty in fixing on a standard of absolutely neutral gray arises from having to work up to a theoretically perfect neutral gray by means of daylight of a variable quality.

Range of Daylight Available for Uniform Readings.—These observations were made on a clear winter day after a heavy fall of snow; the liquid used for measuring was sherry in the 1 inch vessel, and the glass standards were from Color Series No. 52, which is a bright amber.

TABLE NO. 1.

	Sherry in 1 in. Vessel.		Color Series 52.
North light from opal reflector, 2 ft. from instrument	1	matched by	11·75
North light from white blotting paper, 2 ft. from instrument	1	"	11·75
Sunlight from drab wall, 30 ft. from instrument	1	"	11·75
Sunlight from yellow wall 30 ft. from instrument	1	"	11·75
Direct light from cloud over the sun	1	"	11·75 to 11·50
Sunlight reflected from white blotting paper	1	"	11·38
Sunlight reflected through white blotting paper	1	"	10·38
Sunlight from snow 3 ft. from instrument	1	"	10·38
North light from snow 10 ft. off.	1	"	10·75

This table shows, in common with Table No. 2, and also accords with general experience, that all kinds of ordinary daylight between the first approach of twilight and direct rays from the sun are available for ordinary work, so that variations in the color of daylight within wide limits do not alter the readings where the same light is used for both sides.

The Measurement of Incandescent Bodies.—For the measurement of color or intensity in incandescent bodies, whether from a naked flame, molten metal in a furnace, or the sun itself, one tube must command the object either directly or by reflection, while the other tube similarly commands the standard light, to which glsses are added until equal to the object. But if the object is more brilliant or of purer color than the standard light, glasses are added to the object side, reducing its light or color to equal the standard light; in either case the glassss are indices of the difference.

The following table is a measurement of sunlight against a blue sky made on June 26, 1889. The sun was brilliant, and the sky unusually blue, both lights were reflected from Messrs. Chance's opal glass, and the standard glasses were necessarily added to the sunlit side until equality was obtained.

TABLE NO. 2.—COMPARISON OF SUNLIGHT AGAINST A BLUE SKY, BOTH REFLECTED FROM MESSRS. CHANCE'S OPAL GLASS.

June 26th, 1889.	Primary Glass Standards.			
	Red.	Yellow.	Blue.	Total.
9 a.m. Blue sky sunlight	·5	·42	3·1	4·02
12 m. " "	·75	·54	3·6	4·89
7 p.m. " "	·37	·42	2·8	3·63

Among the apparatus on the table is one mounted for showing the color in 6 ft. of water drawn from the service tap of this building; one showing the contrast between two feet of water-white paraffin and two feet of distilled water.

The color-blind measuring apparatus employed in preparing a part of Table No. 3.

The arrangements for measuring ordinary opaque and transparent substances and liquids are also on the table.

An adaptation for measuring the difference of color between two lights, also one for measuring the color in stars; this latter is adapted to a telescope belonging to the Rev. Canon Hutchins of Alderbury, and has been kindly lent me by him for this occasion.

Conclusion.—In submitting this apparatus and method to your judgment, I am fully conscious that there must be many questions which time and more exhaustive work will elucidate, but I am not conscious of having hidden a weakness or exaggerated a strength, and feel sure that when the weaknesses are pointed out, they will act as a spur to further investigation. And in conclusion I wish gratefully to acknowledge the assistance received by me from many quarters; it will be impossible for me to enumerate all. Indeed, in some instances I have no knowledge even of the names of gentlemen who have made valuable suggestions.

I am, however, specially indebted to Mr. H Le Neve Foster, who worked out the method of quantitative estimation of carbon in steel; to Mr. T. Jobson, Jr., of the Stocksbridge works, near Sheffield, who overcame a difficulty in steel solutions of a reddish tinge; to Professor Hummel, of the Yorkshire College, Leeds, who suggested a method of bringing surfaces uneven in texture or color to a suitable condition for comparison by throwing them out of focus with a lens at the eye piece; to Dr. Knecht, of the Technical College, Bradford, for some comparisons in Turkey reds; to Mr. Boverton Redwood for co-operation in working out standards of color for petroleum and cocoanut oils; to Dr. Munro, of the Downton College of Agriculture, for investigation into the method of making ammonia estimations, and for some special work on the color of waters. The fine divisions in the standard scale are mainly the work of one of my daughters.

The working out of the neutral gray equation is the direct result of conversations with Professor Crookes, Professor Church, and Captain Abney, greatly aided by the brilliant lectures of the latter at the Society of Arts last session.

TABLE OF COLOUR MEASUREMENTS OF COMMERCIAL SUBSTANCES.

	200 Red Series.		510 Yellow Series.		1180 Blue Series.		Neutral Gray.		Free Red.		Free Yellow.		Free Blue.
Annatto paste A	13·6	+	11·8	+	5·	=	5·	+	8·6	+	6·8		..
" B	15·75	+	7·25	+	2·25	=	2·25	+	13·5	+	5·		..
PAPER:													
Brown paper	6·6	+	8·3	+	5·4	=	5·4	+	1·2	+	2·9		..
No. 1 writing paper	0·27	+	0·45	+	0·31	=	0·27	+	0·04		..	+	0·04
No. 2 "	0·33	+	0·51	+	0·5		0·33	+	0·18		..	+	0·17
FABRICS:													
Red sateen	28·8	+	6·1	+	5·8	=	5·8	+	23·0		..	+	0·3
Purple velvet	36·0	+	3·3	+	9·6	=	3·3	+	32·7		..	+	6·3
Light blue satin	..	+	1·2	+	4·1								
PAINTS:													
Chrome yellow on paper	2·7	+	12·0										
Orange chrome "	9·8	+	4·5										

FLOUR:	Amber, Series 52.		Brown, Series 50.		Gray, Series 50.
Hungarian E.O.P. No0, Lofty ground	2·0		..		..
" " Fine "	1·75		..		..
Spring wheat flour	..		4·75	+	0·25
English super	0·5	+	2·75		..

CANDLES:	Series 52.		Series 500.
Patent No. 1	1·75	+	0·375
Patent No. 3	3·5	+	·75

MEASUREMENTS OF TRANSPARENT COMMERCIAL COLOURS.

		Series 52.		Total Colour in Degrees.
No. 1 caramel, 1 per cent. solution in ¼-in. vessel		58·0	..	58
No. 2 " " " "		31·0	..	31
		200 Red.	510 Yellow.	
No. A Anatto, 1 per cent. solution in 1-in vessel		1·5 +	16·6 =	18·1
No. B " " " "		1·15 +	8·3 =	9·45
		500 Yellow.		
White mineral oil	1-in. vessel	5·	.. =	5·0
		500.		
Sp. Gr. ·890	1 "	43	.. =	43·0
		200 Red.	510 Yellow.	
Water-white paraffin	24 "	2·9 +	0·510 =	3 41
		52 Series.		
No. 1 glycerin	12 "	6·0	.. =	6·0
		52.	500 Yellow.	
No. 2 glycerin	12 "	9·0 +	0·75 =	9·75
		500 Yellow.		
Syrups from charcoal purifier No. 1, ⅛	"	1·5	.. =	1·5
2, ⅛	"	2·75	.. =	2·75
3, ⅛	"	8·0	.. =	8·0
4, ⅛	"	12·0	.. =	12·0

MICRO CHEMICAL DISTINCTION OF ALKALOIDS AND PROTEIC MATTER.

IN the study of the localization of alkaloids in plants, which is a very important one from the standpoint of vegetable physiology, there sometimes occurs a great difficulty resulting from the fact that certain alkaloids are not possessed of special characteristic reactions.

Although we can have recourse to general reagents only, it must not be forgotten that, without mentioning certain amines and glucosides that are precipitated by iodine, the general reagents of the alkaloids also precipitate most of the proteic matters.

Here is a point that the best chemical works neglect to bring into prominence, and one to which Mr. L. Erreva, who has given much study to the localization of alkaloids in plants, has paid particular attention. In order to supply the existing want, Mr. Erreva proposes to have recourse to solvents of which the use is based upon the fact that the acid salts of the alkaloids are soluble in alcohol, while the proteic matters are not; in fact, among the latter, there is scarcely any save gluten fibrine (extracted by Ritthausen from the gluten of cereals) that seems to form an exception. This is reputed to dissolve in absolute alcohol, but in very minute quantity.

Mr. Erreva's experiments have shown him that alcohol acidulated with tartaric acid (recommended by Stas for the micro-chemical extraction of alkaloids) very well realizes the double desideratum, that of dissolving the alkaloids and precipitating proteic matter, so as to differentiate them micro-chemically. For the preparation of the reagent, Mr. Erreva recommends the following proportions:

Crystallized tartaric acid	1 gramme.
Absolute alcohol	20 c. cm.

Absolute alcohol might be used. In certain cases it precipitates the peptones more completely than the tartaric acid solution does, but it afterward gives less marked precipitates, especially with iodine, and it does not dissolve the alkaloids so well.

Alcohol acidulated with hydrochloric acid (recommended by Gautier) gives excellent results in the dissolving of alkaloids, but it not so well adapted for the precipitation of proteic matters. In fact, as Hoppe-Seyler remarks, the peptones are not precipitated from their aqueous solutions in the presence of free hydrochloric acid.

The alcoholic solution of tartaric acid therefore merits the preference. As for the manner of operating, that consists in soaking in this liquid, for twenty-four hours, sections thick enough to contain one layer of entire cells. The sections are removed from time to time and placed in distilled water and treated with the general reagents —iodide of potassium, double iodide of mercury and potassium, phosphomolybdic acid, etc. If it is a question of alkaloids, these will have been removed by the alcohol, and the general reactions will not have occurred; but if, on the contrary, it is a question of proteins, these will have remained in the cells, and the reactions will have been obtained as before.—*Revue Scientifique.*

INCREASING THE COLOR OF LOGWOOD.

IN a paper presented to the Franklin Institute, W. W. Macfarlane and Philip S. Clarkson call attention to the action of chlorine upon logwood and hæmatoxylin. Dyers know that a decoction of logwood made in contact with the air is much stronger than one made by boiling the wood under pressure in a closed vessel. It is also known that processes have existed for the past forty years for increasing the strength of logwood

decoctions by means of oxidizing agents. For instance, there is an old patent in which the use of chlorates, nitrates and the like for this purpose was protected. The authors, in some preliminary experiments, found that chlorine water had the same effect, and on critical trial they discovered that when chlorine was added in the proportion of four atoms to one of hæmatoxylin, the dyeing strength was increased by 150 per cent. There seems to be little doubt that this is simply owing to the formation of hæmatein.

GYMNASTICS FOR GIRLS.

NOT only have the leading colleges invested in gymnasiums and training grounds more money than would have sufficed a few generations ago for the entire educational work of a decade, but this great outlay has borne fruit in the increased attendance upon the college course, and also in the increased health and manly vigor of the graduates who are yearly turned out into the world to take their places among the ranks of adult workers.

A distinguished professor of Columbia College said recently, in speaking of the new athletic grounds that are soon to be controlled by the Athletic Union, and of the proposed $400,000 gymnasium, the money for which is partially subscribed: "This will make Columbia the leading college in America in athletics, and that will bring more students here, increase our educational facilities, and aid us in becoming the first of American colleges."

The systematic study of physical development has had still another effect, which was explained to me by Dr. John S. White, head master of the Berkeley school.

"Systematic physical development," said the doctor, "has done wonders for Harvard University. For instance, last year there were among the undergraduates over two hundred young men who could satisfactorily pass physical examinations that not a single student could have passed twelve years before that time. Formerly Harvard trained nine young giants who could play ball. Now it trains over two hundred young men, each stronger than the earlier athletes, and all of whom are not only good ball players, but expert general athletes in the gymnasium, on the water, and on the track. That is what systematic study has done in one college."

GOOD FOR THE SHOULDERS AND CHEST.

The systematic study of physical development is not confined exclusively to college students. The preparatory schools in this and neighboring cities have formed an athletic association, and have yearly trials of skill, strength, and endurance, and from their ranks the college athlete of the next generation is almost certain to come.

WOMEN ENTER THE LISTS.

Women were the last to enter the lists. For several years past we have had private gymnasiums where all sorts of physical exercises have been taught, including even boxing and fencing, but with the formation of the Berkeley Athletic Club for ladies and the building of the Berkeley Lyceum the gauntlet was formally thrown down and the word "athlete" may now be either masculine or feminine in gender.

With the formation of the Berkeley Club there also came a number of other physical culture schools with their various founders and disciples, their different systems and adherents, with and without public lectures, some successful and some unsuccessful, but all aiming at one object, and that object the physical development of the gentler sex.

A FAVORITE LEG EXERCISE.

One day recently, accompanied by a *Herald* artist and photographer, I called upon Dr. Mary Taylor Bissell, medical director of the Berkeley Ladies' Club, and arranged with her and with Miss D. M. Elliott, the instructor of the club, for a series of instantaneous photographs and sketches that would explain to the *Herald* readers precisely what kind of work has been adopted by the leading physical trainers of women in America for their class and individual instruction. All of the illustrations were made under the supervision of the doctor and Miss Elliott, and together with the text will present the first complete article upon calisthenic exercises, as practiced by American women, that has ever been made public.

OPINION OF A MEDICAL EXPERT.

"Exercise alone, of all the agents of growth and development, can be regarded in an educational light," explained the doctor. "Of all the agents, it alone can be permanently systematized and administered as a means of progressive bodily culture. No other agents have their rules which are modified to suit age, seasons, habits, and occupations. These all have their importance, and upon their observation bodily health largely depends, but we look to exercise almost exclusively as the means of actual physical culture during the greater part of the period of growth and development.

THE PARALLEL BAR EXERCISE.

"Exercise," continued the doctor, "is a muscular movement, but it must be a movement of sufficient force to engage the energetic contraction of the muscles employed. When a girl comes to me for a course of physical development, I first examine her carefully. It is such an examination almost as a life insurance company follows before a policy is granted. I ask her age, the ages of her parents if living, or their ages at the time of their death, and I learn of what diseases they died. Then I closely question her regarding her own health, and learn what, if any, ailment she has had.

THE VALUE OF MEASUREMENT.

"After this come the physical measurements. These are very exact, and few learners at first see their value. But they are valuable. Before I can prescribe physical training for a young woman I must know her condition and her measurements, and I must see wherein her weaknesses, if she have any, or wherein her physical defects lie. Otherwise how can I understandingly suggest the best mode of exercise for her to pursue?

"I keep a record of the length and size of her chest, waist, arms, and legs, and I carefully test her strength of lungs, back, legs, chest, upper and fore arms. When she has been at work a few months I repeat these tests, and no one is more surprised than the girl, who once thought these records were utterly worthless, to find what improvement she has made—an improvement that can be seen with the eyes and can also be proved by figures.

"Now for the exercise. Miss Elliott will tell you her first steps."

THREE BAD STANDING POSITIONS.

"I generally find," said Miss Elliott, "that girls do not know how to stand correctly, and I begin with the 'setting up' drill. Many girls are in the habit of standing with their backs bent over, their shoulders thrown forward, heads dropped and chests sunk in. Others protrude their hips and abdomens, and still others rest their weight unevenly upon their legs. These are the three chief defects I meet with."

THREE BAD POSITIONS.

While Miss Elliott was explaining these popular shortcomings the young lady who posed for the *Herald* artists illustrated the positions, and the accompanying sketches will give the reader a clear idea of some of the chief things that intelligent physical culture aims to correct.

"This 'setting up' drill," continued Miss Elliott, "consists of a great variety of movements made with the hands, arms, body, and legs, with and without using the gymnasium apparatus, and all tend to throw back the head and shoulders, inflate the chest, draw in the hips and abdomen and give the body an upright and graceful carriage. Let us take the first series."

THE SETTING UP DRILL.

Then at this point the photographer caught the model in the first position of this series, while the artist made a sketch of the remaining movements that complete the exercise. This looks simple enough, and to such expert gymnasts as Miss Elliott it is unquestionably simple, but the untutored learner finds it difficult enough to give her a very gloomy idea of her prospective course in bodily training.

ONE OF THE FIRST PRINCIPLES.

"It is singular," explained Dr. Bissell, "but it makes no difference how well a young lady may have her hands and fingers under control. She may be an unusually brilliant performer upon the piano, or she may be a remarkably graceful dancer and have her legs and feet under perfect control, but when she tries these exercises, and particularly when she combines any of these movements, such as moving her right arm in one direction, her left arm in another, and at the same time moving one of her legs, she makes a lamentable failure at first. Systematic physical development also develops the brain and will power. It gives the will control over the nerves that communicate orders from the brain to the various muscles. Our system develops the body and the character as well. As has been said by a distinguished English writer:

"'It increases the size and power of the voluntary muscles employed.

"'It increases the functional capacity of the involuntary muscles employed.

"'It promotes the health and strength of the whole body by quickening circulation and increasing respiration.'"

A DIFFERENT POSE.

The "setting up" drill consists of various movements to render the joints of the waist, back, thighs, and

BENDING TO THE FLOOR.

knees supple and active. A second illustration explains a very useful exercise. The learner is taught to stoop down and touch the floor with her finger tips and then straighten herself without losing her equilibrium.

Besides these she goes through a course in stooping until she almost touches her body to the floor, and then raising herself to her full height upon the tips of her toes.

In addition to these exercises Dr. Sargent, the famous director of the Hemingway Gymnasium, of Harvard University, has invented numerous appliances which give mechanical aid to the learner's efforts. Of these aids more will be said hereafter.

"After the 'setting up' drill," continued Miss Elliott, "I teach the learner how to walk correctly. One should walk directly from the hip, bringing the weight on the ball of the foot."

HOW TO STEP CORRECTLY.

The accompanying illustration shows how a step should be correctly taken.

After the first principles of walking have been mastered the learner is put through a course of skipping,

HOW TO STEP CORRECTLY.

pacing, and even running, care being taken to preserve the positions taught in earlier exercises.

"Now come free gymnastics," said Miss Elliott. "These comprise almost every exercise in the entire range of calisthenics. They are made with the arms,

hands, body, head, and legs. They strengthen the muscles, produce activity, and give the brain instant control over every member of the body. There are many different courses of exercises calling into play various muscles and parts of the body, and even a simple list of all the movements would be more than sufficient to fill several columns of the *Herald*."

FREE GYMNASTICS.

Here are two illustrations of a simple exercise in free gymnastics—not one of the simplest in the list, but one that is not extremely difficult to acquire.

The first shows a well known movement of the lower part of the body that is designed to call into activity the internal and external muscles of the thigh.

The second is a "waist movement," and is intended to exercise all those muscles of the body that control the action of bending.

TO STRENGTHEN THE WAIST.

"Free gymnastics," said the doctor, "have their value, and it cannot be easily overestimated, but for individual work I think our gymnasium apparatus, which has been devised especially for our club by Dr. Sargent, produces quicker results. All that free gymnastics, either simple or complex, will accomplish can be done with the apparatus in a shorter space of time."

Chief among the mechanical appliances which have been devised for making women stronger are the wands, bar bells, and dumb bells.

The accompanying illustration shows the model

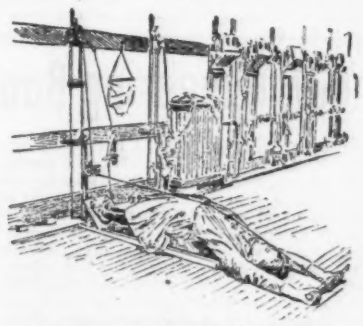
WORK WITH A BAR BELL.

going through an exercise with a bar bell, which is a wand with two bell-shaped knobs, one at each end. This exercise is intended to develop the muscles of the waist and arms and shoulder. It also distends the chest.

Another bar bell exercise is also illustrated. The arms are outstretched and the chest and back are given an abundance of work. It is one of the most valuable exercises in the list.

THE CHEST WEIGHTS.

The chest weights machine is one of the most valuable appliances that Dr. Sargent has yet devised. It is



ON THE ROWING MACHINE.

a combination contrivance. In the accompanying cut the reader sees it when being used as a rowing machine.

WORK WITH THE CHEST WEIGHTS.

It consists of a pulley which may be made harder to raise by pulling on the weights. It can be used with one or both hands. It can be changed into a rowing machine, a head machine (a contrivance intended to strengthen the muscles of the neck and to hold her head upright), and a leg machine. This latter device consists of an attachment that looks like a stirrup, and into which the operator's foot fits. By means of it she exercises all the muscles of the leg and thigh.

Dr. Bissell gave me a copy of her courses of movement on the chest weights machine that will be found of great value by persons who desire to become athletes. This machine can be put up in a private room, and the learner requires no instruction for her exercise other than these lists of movements, which are here for the first time made public.

The first course is as follows:

A VALUABLE COURSE.

Position to weights.	Order.	Movements.
1. Face	Forward and back	Left and right alternating.
2. Face	Straight arm downward. Body erect	
3. Face	Bent arm upward	
4. Back	Straight forward. Shoulder high	Both together.
5. Back	Straight arm backward. Head erect.	Both together.
6. Back	Bent arm over head. Body motionless	Both together.
7. Right side	Right arm downward to side	Right only.
8. Left side	Left arm downward to side	Left only.
9. Left side	Right arm across the chest	Right only.
10. Right side	Left arm across the chest	Left only.
11. Left side	Right arm behind the head	Right only.
12. Right side	Left arm behind the head	Left only.
13. Left side	Right arm behind the back	Right only. Palms upward.
14. Right side	Left arm behind the back	
15. Face	Down and up	Both together.

The preceding photograph shows the model going through with No. 4 of the preceding list.

"After going through with this course," said the doctor, "I would advise the second course. The movements, as you will see, are nearly all complex, and the value of complex movements in educating the brain, nerves, and muscles to work harmoniously together cannot be overestimated.

"For instance, look at exercise No. 6 of the second course. You will see that the right arm is extended straight out, while the left arm is brought down across the body. While this exercise may look very simple to you, it is really very difficult. I don't suppose one woman out of forty can go through with it the first time it is explained to her without becoming mixed up. It is such exercises as this that develop the character and strengthen the will."

The second course is as follows:

FOR ADVANCED STUDENTS.

Position to weights.	Order.	Movement.
1. Face	Bent arms, back to shoulders	Both together.
2. Face	Left straight down, right up	Both together.
3. Face	Right straight down, left up	Both together.
4. Left side	Left arm down to side	Both together.
	Right arm across chest	Both together.
5. Right side	Right arm down to side	Both together.
	Left arm across chest	Both together.
6. Left side	Right arm straight out	Both together.
	Left arm down across body	Both together.
7. Right side	Left arm straight out	Both together.
	Right arm down across body	Both together.
8. Left side	Right arm behind back	Both together.
	Left arm diagonally upward	Both together.
9. Right side	Left arm behind back	Both together.
	Right arm diagonally upward	Both together.
10. Back side	Forward under arms	Both together, palms in.
11. Back side	Right arm bent over shoulder	Both together.
	Left arm down, forward	Both together.
12. Back side	Left arm bent over shoulder	Both together.
	Right arm down, forward	Both together.
13. Left side	Right arm upward and outward	Alternately.
	Left hand across body under high arm	Alternately.
14. Right side	Left arm up and out	Alternately.
	Right arm across body under left arm	Alternately.
15. Face	Straight down, bending at hips	Both together.
	Up to shoulders. Repeat and raise handles above shoulders.	

SOME DUMB BELL EXERCISES.

Equally as important as the bar bells are the dumb bells. The following are illustrations of two movements:

The first is designed to exercise the shoulders, back, legs, and chest.

A USEFUL DUMB BELL.

The second is a complex movement, and is intended to develop the strength of the arms, waist, chest, and shoulders.

A COMPLEX DUMB BELL EXERCISE.

These two exercises are only two out of a hundred that might be given. The dumb bell courses, like those with the wands, bar bells, and chest weights, are susceptible of endless variations.

The triceps machine is another of Dr. Sargent's inventions. It looks something like a window sash, and the exercise seems generally to the novice to be extremely foolish. But foolish it is far from being. It develops the muscles of the arm, and it develops them quickly and well.

One who had not trained for a season, at least, in a well appointed gymnasium would not appreciate the value of this sort of exercise. It is step by step, inch by inch, but its results cover miles and pounds. It is necessary for the beginner to work steadily at just this kind of exercise The muscles grow daily stronger, and after a few months have passed no one is more surprised than the learner at the gain that is attained.

ON THE TRICEPS MACHINE.

The accompanying cut illustrates the machine.

When the triceps are well developed, the athlete turns to the parallel bars for the best chance to show her newly acquired strength

THE TRICEPS MACHINE.

Now here comes a queer exercise with a still queerer name. It is called the chinning exercise, and it is performed on the chinning machine. The sketch of the model will explain to the reader what chinning is. It

AT THE CHINNING MACHINE.

strengthens the arms and gives the learner that particular skill which is called into play when she "chins" on flying rings.

To chin one's self, as the photograph given herewith shows, is to lift one's weight by one's hands from the floor so that the chin will touch the tips of the fingers.

CHINNING THE TRAPEZE.

It is an exercise that requires more skill than strength, although the latter must be present to a not inconsiderable extent.

CLIMBING THE ROPE.

There are several different kinds of ropes in the Berkeley gymnasium. The plain rope, the knotted rope,

and the beaded rope, called by English authorities the "rosary." The last is a very simple device which can be used by the climber either with her hands or feet. It is usually only used by beginners.

Climbing the rope is one of the exercises that the Berkeley young ladies are taught, and some of the more advanced members are expert climbers.

The plain rope is the hardest to climb, and it requires more muscle almost than any other exercise that is practiced.

The artist made a snap shot photograph of the model as she was illustrating how easy it is to climb the smooth rope when you have the necessary strength and skill.

ON THE HORIZONTAL BAR.

"I don't know," said Miss Elliott, as the model pulled herself atop the horizontal bar and prepared to make what school boys twenty years ago called 'the giant's swing'—"I don't know that this exercise requires

ON THE HORIZONTAL BAR.

much strength, but it certainly does bring into play plenty of skill, and any one who can go through with it must have lots of muscle and practice. It is worth while illustrating to show you what sort of exercises our young ladies can learn after they are far enough advanced. At the present time this is a trifle beyond them."

The last illustration shows one of the most valuable appliances that is known to the muscle culturist. It is called the "quarter circle chest expander." The accompanying picture will prove to you whether it is misnamed or not. The model is shown stretched out

THE QUARTER CIRCLE.

on the machine in the act of having her lungs distended and her chest expanded.

"How long do you advise women to exercise?" I asked Dr. Bissell.

"Not more than one hour a day. I recommend steady exercise where it is practicable, and prefer that the members should take it daily. But I do not approve of long hours for physical work.

"When a young lady joins the club, I measure her and examine her carefully as to her health, as I have explained to you. Then I give her a copy of the following card. This will show you how close a supervision we exercise over our members, and to this close supervision the health and strength of the young ladies are largely due. Each exercise, as you will see, is designated in the card, and this prescription is followed to the letter by Miss Elliott."

Here is the card:

EXERCISE.

Use apparatus 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40.

Times—10, 15, 20, 25, 30, 35, 40

Rate per minute—20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42, 44, 46, 48, 50, 52, 54, 56, 58, 60.

Weight—2½, 5, 7½, 10, 15.

Hour in day.

Running.

Sports—Tennis, bicycling, boating, skating, fencing, riding, driving, swimming.

Bath—Hot, cold, tepid, sponge, needle, plunge.

Diet—Meat, fish, vegetables, eggs, butter, fruit, bread, milk, coffee tea, chocolate.

During the past year, which is the first year in the Berkeley club's history, there has not been a single serious accident in the gymnasium. One young woman slightly sprained her ankle, and that was the extent of the injuries sustained by the club, either individually or collectively.—*New York Herald.*

THE GIANT OF AQUILA.

THE Italian press announces the death of the famous giant, Joseph Catonio, which occurred on the 9th of March at Acciano (a province of Aquila), his native country, where he had lived for thirty years. Catonio had his period of celibrity among us. King Louis Philippe, in 1845, attached him to the *personnel* of the Tuileries, and it was no small subject of astonishment to the visitor to find himself, on entering, face to face with this 7¼ foot porter, who was taller than the most gigantic of the drum majors of the royal guard, inclusive of the fur shako and plume. The cook of the palace had orders to prepare a dinner for him capable of satiating four of his colleagues. The biographers of this giant complacently tell us that he covered a five franc piece with his enormous thumb. His waistbelt was capable of serving as a bellyband for a good sized horse. The king and the royal family seemed to be particularly flattered to possess a servant of so imposing a presence, and whose correct and martial attitude many a time excited the jealousy of princely visitors, who would have desired to attach him to their persons.

Catonio, who was the son of poor peasants, was taken to Paris by some showman, who exhibited him for a certain length of time. History does not tell us how he obtained the signal favor of donning the uniform of a royal porter. All that is known is that, upon the fall of the government of July, Catonio, like his master, went into exile, traveling over the country and picking up the money of the curious who were admitted to contemplate him.

Catonio willed his body to the anatomical museum of Rome. In a few months, visitors to that establishment will be able to view the skeleton of the old giant porter of the Tuileries. We believe that it will be a unique anatomical specimen of the kind.

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